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MANNED MISSION HIGHLIGHTS

'TASS'ANNOUNCES LAUNCHING OF 'SALYUT-7' SPACE STATION

Moscow PRAVDA in Russian 21 Apr 82 p 1

[Text] In accordance with the program for space research, on 19 April 1982 the orbital scientific station "Salyut-7" was launched in the Soviet Union.

The "Salyut-7" station was inserted into a near-earth orbit with the following parameters:

--apogee, 278 kilometers;

--perigee, 219 kilometers;

--period of reviolution, 89.2 minutes;

--inclination, 51.6 degrees.

The purpose of the launch of the "Salyut-7" station is to continue scientific and technical studies and experiments conducted on manned Soviet complexes in the interests of science and the national economy. In addition, in the course of the flight there will be tests of improved systems and apparatus of orbital stations.

Control of the flight of the "Salyut-7" station is being carried out by the Moscow Control Center, tracking stations on the territory of the Soviet Union and the scientific research ship "Akademik Sergey Korolev" located in the Atlantic Ocean.

According to telemetry information the on-board systems of the "Salyut-7" station are operating normally.

CSO: 1866/83-P

CHRONOLOGY OF 'SALYUT-7' FLIGHT

[Editorial Report] The Soviet News Agency TASS reports the following information on activities connected with the flight of the "Salyut-7" space station:

13 May

At 1358 hours Moscow time on 13 May the "Soyuz T-5" spacecraft was launched. The crew consists of mission commander Lt Col Anatoliy Berezovoy and flight engineer Pilot-Cosmonaut of the USSR Valentin Lebedev. The mission program calls for docking with the "Salyut-7" station launched on 19 April and performance of a complex of scientific and technical research. (Moscow TASS in English 1238 GMT 13 May 82)

14 May

After a correction maneuver the parameters of the "Soyuz T-5" are: apogee, 326 km; perigee, 261 km; period of revolution, 90.3 min; inclination, 51.6 degrees. Cosmonauts Berezovoy and Lebedev are preparing for the link-up with "Salyut-7". (Moscow TASS in English 0819 GMT 14 May 82) At 1536 hours Moscow time the "Soyuz T-5" docked with "Salyut-7" and the cosmonauts transferred to the station. The "Soyuz T-5" was docked on the side of the station's transfer compartment. The program of the mission includes:

- --studies of the earth's surface and atmosphere for various sections of the national economy;
- --Astrophysical, medico-biological studies and technological and technical experiments;
- --Tests and adjustments of the improved systems and apparatus of the orbital station.

Successful commencement of work aboard the "Salyut-7"--"Soyuz T-5" complex is a major step forward in the creation of permanently working orbital stations. (Moscow TASS in English 1633 GMT 14 May 82)

15 May

Parameters of the "Salyut-7"--"Soyuz T-5" complex are: apogee, 360 km; perigee, 343 km; period of revolution, 91.3 min; inclination, 51.6 degrees. In accordance with the plan for activating the station, the cosmonauts are checking the life support, energy supply and thermal regulation systems. The cosmonauts adjusted the "Stroka" teleprinter, checked the radio communication equipment and monitored the atmosphere inside the complex. Microclimate parameters inside the complex are: temperature, 20 degrees C; pressure, 840 mm Hg. The cosmonauts' adaptation to weightlessness is proceeding normally. (Moscow TASS in English 1210 GMT 15 May 82)

16 May

The working day began at 1000 hours Moscow time and will last until 2400 hours. The cosmonauts are continuing planned operations for activation of the station's systems. Control checks on the "Delta" system of autonomous navigation have been started. (Moscow TASS in English 1404 GMT 16 May 82)

17 May

Cosmonauts Berezovoy and Lebedev placed into orbit the small artificial earth satellite "Iskra-2". The cosmonauts put the satellite into open space through the air lock chamber. Orbital parameters of "Iskra-2" are: apogee, 357 km; perigee, 342 km; inclination 51.6 degrees; period of revolution, 91.3 minutes. The "Iskra-2" satellite was created by the student design office of the Moscow Aviation Institute imeni Ordzhonikidze. It carries a retransmitter for experiments in amateur radio communication, a memory device, a command radio channel and a radio telemetry system. Student reception and command centers in Moscow and Kaluga are controlling the satellite and receiving incoming information. (Moscow TASS in English 1458 GMT 17 May 82)

18 May

In their fifth day aboard the "Salyut-7"--"Soyuz T-5" complex the cosmonauts are continuing to prepare scientific instruments for scheduled research and experiments. The cosmonauts have examined the station's viewports and checked the serviceability of their protective covers. They also loaded film in the station's cameras and tested them in operation. Both the commander and the flight engineer will exercise today on the treadmill and stationary bicycle. (Moscow TASS in English 1132 GMT 18 May 82)

21 May

The cosmonauts have completed their first week aborad the orbital complex. According to Doctor of Medical Sciences Anatoliy Yegorov, the crew's adaptation to weightlessness is proceeding better than expected. The organisms of the cosmonauts had already returned to the norm on the second day of the flight. The "Aelita", a new multipurpose medical unit, is being used aboard "Salyut-7" to check and evaluate the state of the cosmonauts' cardiovascular systems, cerebral activity, arterial pressure and minute volume of blood circulation. The "Aelita" presents an interconnected picture of the life activity of the organism as a whole. (Moscow TASS in English 0918 GMT 21 May 82)

23 May

At 0957 hours Moscow time the unmanned cargo craft "Progress-13" was launched. Orbital parameters of "Progress-13" are: apogee, 278 km; perigee, 191 km; period of revolution, 88.9 min; inclination, 51.6 degrees. (Moscow TASS in English 0932 GMT 23 May 82)

25 May

At 1157 hours Moscow time "Progress-13" docked with the "Salyut-7"--"Soyuz T-5" complex on the side of the station's service module. Rendezvous and docking were accomplished by commands from the mission control center and with the help of on-board automatic systems. "Progress-13" delivered fuel for the combined propulsion system, life-support and research equipment as well as mail for the cosmonauts. (Moscow TASS in English 0923 GMT 25 May 82)

28 May

Cosmonauts Berezovoy and Lebedev have completed their second week of work aboard "Salyut-7". Unloading of the "Progress-13" craft is proceeding on schedule. The tanks of the station's joint propulsion system have been refuelled. The cosmonauts are observing and photographing areas of the earths surface, including agriculture areas in Krasnodar, Central Asia and the Volga region. Experiments in the development of higher plants in space flight conditions are continuing aboard the orbital station. The cosmonauts reported that oat and bean seeds have germinated on the "Oasis" installation. Their growth is recorded automatically by a movie camera. All on-board systems are functioning normally. (Moscow TASS in English 1110 GMT 28 May 82)

1 Jun

The cosmonauts have practically completed all planned operations with "Progress-13". Water has been pumped into the station's tanks with the help of the "Rodnik" system. The joint propulsion unit has been refuelled and filled with oxidizer. Equipment brought to the station has been stowed and the empty compartments of "Progress-13" are being loaded with used life-support equipment. The cosmonauts are preparing for work with the MKF-6M multi-band photographic equipment for further study of earth resources. A trajectory correction of the orbital complex will be made tomorrow using the propulsion unit of the "Progress-13" ship. (Moscow TASS in English 0916 GMT 1 Jun 82)

4 Jun

At 1031 hours Moscow time the "Progress-13" transport craft separated from the "Salyut-7"--"Soyuz T-5" complex after completion of all planned operations. Cosmonauts Berezovoy and Lebedev are in their fourth week aboard "Salyut-7". Their schedule for today includes an appraisal of the microclimate parameters inside the complex, biological research and a check of the equipment for monitoring the characteristics of the ionosphere and atmosphere of the earth, including the atmosphere around the complex. The cosmonauts' state of health is good and they have a high capacity for work. (Moscow TASS in English 1136 GMT 4 Jun 82)

6 Jun

At a command from the flight control center today the "Progress-13" craft was reoriented in space and at 0405 hours Moscow time its engines were activated. "Progress-13" entered the dense layers of the atmosphere over the Pacific Ocean and ceased its existence. Today the cosmonauts will exercise, conduct studies of the earth's surface and rest. (Moscow TASS in Russian 1100 GMT 6 Jun 82)

8 Jun

In the program of geophysical experiments the cosmonauts are using spectral and radiometric equipment and the MKF-6M and the KATE-140 cameras for observation and photography of the earth's surface. Observations are being made of agricultural areas in different parts of the country. On assignment from geologists, the crew are continuing studies of large circular formations and fractures of the earth's crust to aid in planning exploration for mineral deposits. The cosmonauts are also observing the world ocean to spot areas of commercial fishing. (Moscow TASS in English 1114 GMT 8 Jun 82)

CSO: 1866/100-P

'VENERA-13' AND 'VENERA-14' DESCENT CRAFT LAND ON VENUS

[Editorial Report] The Soviet News Agency TASS reports the following information on the landings and experiments of "Venera-13" and "Venera-14":

At 0555 hours Moscow time on 1 March the "Venera-13" descent craft entered the dense layers of the atmosphere of Venus at a speed of 11.2 kilometers per second. The lander descended by parachute to an altitude of 47 kilometers and made the final descent with the aid of an aerodynamic braking device. Sixty-two minutes after entering the atmosphere, the lander touched down in an area east of the Phoebe region with the coordinates of 7 degrees 30 minutes south latitude and 303 degrees longitude. Data was transmitted from the surface of the planet for a period of 127 minutes. Panoramas of the surface were transmitted to earth by telephotometers. Some of the panoramas were photographed consecutively through red, blue and green filters which will make it possible to obtain color pictures of the surface of the planet for the first time. The lander also carried a soil sampler device which drilled a rock sample at the ambient temperature of 457 degrees and a pressure of 89 atmospheres. The sample was transmitted to a hermetically sealed chamber for X-ray fluorescence analysis. At the same time, a detachable device measured seismic activity and the physical and mechanical properties of the surface. (Moscow TASS in English 1330 GMT 1 Mar 82)

At 0553 hours Moscow time on 5 March the "Venera-14" descent craft entered the atmosphere of Venus. Sixty-three minutes later the craft landed in an area to the east of the Phoebe region with the coordinates of 13 degrees 15 minutes south latitude and 310 degrees 9 minutes longitude. Surface temperature was 465 degrees; pressure was 94 atmospheres. Panoramas of the surrounding terrain were taken through colored filters. A soil sample was analyzed to determine the composition of the rocks on the new site. Measurements of electrical conductivity were made and the physical and mechanical properties of the soil and the planet's seismic activity were assessed. (Moscow TASS in English 1228 GMT 5 Mar 82)

CSO: 1866/93-P

'VENERA' DATA ON ATMOSPHERE AND SURFACE COMPOSITION

Moscow PRAVDA in Russian 3 Mar 82 p 3

[Article by Yu. Surkov, professor, doctor of physical and mathematical sciences, Lenin Prize laureate: "A Portrait of the Morning Star"]

[Text] As I began writing this commentary about the flight of 2 more Soviet automatic stations to Venus, I remembered a certain discussion which occurred on a spring day in 1966. Astronomers, planetologists, space chemists had come together with designers and engineers in the office of Academician M. V. Keldysh to discuss the final points of the "Venera-3's" journey, and the scientific problems which had to be resolved during the next flight to this planet.

Participating in the discussion was the famous Soviet designer of space instruments, G. N. Babakin; with work on "Venera-4" still lying ahead for him, he asked those present a seemingly elementary question: what should be considered as the basic component of Venusian atmosphere--nitrogen, like on Earth, or carbon dioxide, traces of which were discovered by spectroscopy from Earth? This was not merely an expression of inquisitiveness, which is one of his characteristic traits--he needed to know what to plan for in the instrument that would descend into the Venusian atmosphere, since the loads it would experience upon entering a carbon dioxide atmosphere of a planet would be approximately one and a half times greater than upon entering one of nitrogen.

There was no definitive answer. The scientists parted discussing not only what the atmosphere basically consists of, but also its density. The expressed hypotheses covered a wide range of atmospheric pressures on the planet's surface--from one to one hundred atmospheres.

This episode I recall illustrates how little we knew about Venus only fifteen years ago.

Why did Venus in particular become the object of special attention during the past years? There are several reasons. Venus is the only one among the planets of this solar system close in size and mass to Earth. The study of Venus gives an opportunity to better understand the evolutionary history of Earth. Venus comes close to Earth more often than other planets, which permits regular--once every one and a half years--launching of space vehicles toward it. Finally, since it's completely enveloped by a cloud layer, we know the least about Venus. This has raised numerous conflicting and often fantastic hypotheses.

Answers to some of the important questions were already provided by "Venera-4", which made a slow descent in its atmosphere in 1967. It turned out its atmosphere is 97% carbon dioxide.

Since that time, ten more Soviet automatic stations have been sent to Venus. Step by step, overcoming severe climatic conditions that exist on the planet (the temperature on its surface is about 500°C, and the pressure approximately 90 atmospheres), they uncovered its secrets.

Naturally, greatest attention was devoted to study of the atmosphere, which determines not only the appearance of the planet and the nature of the surface, but to a certain degree determines its inner structure. The atmosphere of Venus turned out to be completely unlike that of Earth. Such components as nitrogen, oxygen, water vapor from which the aerial oceans of Earth are formed, exist only in small or negligible quantities in the Venusian atmosphere. This has caused some consternation among scientists. An explanation was soon found, however. It turned out that the majority of the volatile components that formed during the degassing of the melting crust, are approximately the same on both planets. And the current differences in the atmosphere of Earth and Venus are proof of the varying stages in their evolution. It appears that Earth too had a dense carbon dioxide atmosphere in the distant past which then developed into a nitrogen-oxygen atmosphere over time.

It was more complicated to develop a history of water on Venus. Water cannot exist on the surface of a planet under such high temperatures and it is found in trace quantities—less than 0.1 per cent—in the atmosphere. Conversely, there is enough water on Earth to cover the entire surface with a three kilometer layer.

Where did the water go and did it ever exist on Venus?

The data scientists have does not provide a precise answer. Some researchers believe there never was any water in large quantities on Venus. Others believe that Venus had water in an earlier period, but that the water was gradually precipitated into the atmosphere and dissociated under the influence of the sun's ultraviolet rays. A third group of researchers assumes the presence of water in bound forms in surface rock; the amount, however, should be considerably less than what is found in the world oceans of Earth. There are other opinions still. Experiments to study the atmosphere and surface of the planet have been planned for "Venera-13" and "Venera-14" stations, which will make it possible to narrow down the range of hypotheses.

While a great deal is known about the atmosphere of Venus and scientists have arrived at a definite opinion about its origin and evolution, the nature of Venus' clouds, which are discovered by M. V. Lomonosov more than 200 years ago, remains a riddle to a large degree. The altitude and composition of the clouds are known. It has been determined, in particular, that the clouds of Venus are not dense, but rather resemble fog or haze, extending approximately 45 to 70 kilometers above the surface. The density of the clouds changes with altitude, which points to their complex composition, and perhaps, their non-homogeneous chemical composition. Regardless of the mighty veil of clouds, however, sunlight reaches the surface of Venus and day is bright there, like an overcast day on Earth.

The nature of Venusian clouds still remains unclear today. Some indirect evidence indicates that they consist of drops of sulphuric acid. To a certain degree, this is supported by an examination of the thermodynamic interaction of surface and atmosphere. It would appear that one could take this point of view with conviction. Not too long ago, however, "Venera-12" discovered more chlorine than sulphur in the Venusian clouds and the question was suddenly complicated once again.

The "Venera-13" and "Venera-14" stations are equipped with gas chromatographs and a mass spectrometer intended to determine the chemical and isotope composition of the atmospheric gases; an X-ray spectrometer to determine the components of aerosole particles within the cloud layer; a spectrometer to analyze the diffusion of sunlight by the atmosphere and clouds, and other instruments. Some of them are being utilized in space exploration for the first time.

As we know, "Venera-9" and "Venera-10" opened the cloud cover of this planet for the first time in 1975. The panoramas they transmitted of its surface told about the amazing world of this distant heavenly body which is amazing no so much for its differences, but rather for its similarity to the relief and geologic formations of Earth, although the physical conditions of these planets sharply differ.

The stations were set down in regions 1,500 kilometers apart from each other, and naturally, the geologic conditions turned out to be different. The "Venera-9" camera showed the slope of a hill covered with a small-grained material that resembled the halo-like scattering surrounding meteorite craters on Earth. The "Venera-10" station essentially photographed eroded bedrock, covered in some areas with small-grained material of impact or aeolian origin. And although these two areas do not resemble one another, similar places can be easily found on Earth. Both panoramas showed a landscape that is characteristic of planets that have atmospheres (Earth, Venus, Mars), as opposed to the landscape of those heavenly bodies without an atmosphere (Moon, Mercury).

Radar with the aid of space instruments and radiotelescopes on Earth made it possible to determine the features of large formations on the Venusian surface. It was discovered the surface is smoother than that of Earth. On the average, elevation and depth deviation does not exceed three kilometers. Hilly regions, rolling plains, large-scale depressions and huge ring formations that resemble craters of impact origin with diameters of more than 100 kilometers have been identified. Their depth is several times less than that of craters of a corresponding diameter on the Moon.

How can the absence of deep depressions be explained? Either they never formed, or were destroyed during the evolution of the crust, or were covered by deposits. If these craters, like those of the Moon, occurred as a result of large meteoric bodies, then they must have formed in the early part of the existence of Venus. Their ancient age, in that case, attests that processes that altered the surface of Venus are less effective than those of Earth.

Thus, one hand, the available data points to the existence of ancient regions which, it appears, changed little from the time craters of impact origin were formed, while on the other hand, they provide a number of indications that Venus is a geologically active planet, one which possibly will not yield to Earth in terms of variety of geologic formations. The pictures, as we can see, are for now contradictory.

To develop an understanding of Venus it is important to determine the component nature of the surface soil and the conditions under which it formed. In this regard, we command very limited data at present. However, research on certain physio-mechanical properties--density, rigidity, composition and others--has shown that the surface of Venus is covered with rock that has the high density and durability, with the low porosity characteristic of volcanic eruptions. The most important information in this regard is the fact that the soil layer contains some natural radioactive elements--uranium, thorium, potassium--in those regions where Soviet automatic stations have landed before.

At the landing site of "Venera-8", the content of natural radioactive elements turned out to be the highest, almost similar to granite formations on Earth. This region has an old surface densely covered with craters. In terms of soil type, the crater resembles continental portions of the Earth's crust.

The "Venera-9" and "Venera-10" stations discovered a much lower content of radioelements, corresponding to that of Earth's basalts. These stations transmitted information from the slopes of the Beta elevation--apparently a rather yound region of basalt vulcanism.

We are now impatiently awaiting the results of data analysis of the element composition of surface layer components. The precise operation of the Soviet drilling apparatus on the Venusian soil is an amazing experiment from the point of view of daring conceptualization and skill of execution. It has demonstrated the matured opportunities of our national cosmonautics, and its growing contribution to the study of the universe in the name of scientific progress to benefit all mankind.

Thus, as a result of the flights of Soviet automatic stations to Venus, much of the history of this mysterious planet has been cleared up. However, new dilemmas have arisen. "Venera-13" and "Venera-14" will bring an important contribution to solving them and will help develop understanding about the origin, evolution and present structure of bodies in the solar system.

9875
CSO: 1866/70

'VENERA' FINDINGS ON VOLCANIC AND ELECTRICAL PHENOMENA

Moscow PRAVDA in Russian 8 Mar 82 p 7

[Article by L. Ksanfomaliti, doctor of physical and mathematical sciences, Moscow: "Lightning Above Volcanoes"]

> [Text] The scientific program performed by Soviet spacecraft "Venera-13" and "Venera-14" is significantly broader than that of its precursors. "Venera's" of the past essentially studied the atmosphere. The new instruments were intended to conduct experiments related to study of atmosphere and surface of the planet in equal measure.

The logic of research brings about constant sophistication of scientific programs of the "Venera" stations. The first instruments that reached the planet's surface informed us of the high temperatures and pressures that dominate there (for example, at the landing site of "Venera-13"--it was 457 degrees Celsius and 89 atmospheres), and also determined the principal component of the atmosphere--carbon dioxide (96 per cent). The cause of the high temperature on the Venusian surface is the low atmospheric transmittance of carbon dioxide (with a small admixture of water vapor) through infrared rays. Only a small portion of sun-derived heat is reflected back into space. The rest remains under a thick "blanket" of the atmosphere.

Launched in 1978, "Venera 11 and -12" performed an analysis of the microelements in the atmosphere, such as nitrogen, inert gases, water vapor, gaseous compounds of sulphur, and others. Even earlier, in 1975, "Venera-9 and -10" studied the composition of the clouds by various methods. The clouds are located high above the surface--from 49 to 70 kilometers. A thin layer of similar fog is found in Earth atmosphere as well--at a great height--but as we know, in our atmosphere clouds consist primarily of water drops. Venus, however, is water-poor. Naturally, the high temperatures on its surface completely preclude the existence of any sort of water reservoirs.

If the oceans were evaporated the pressure in our atmosphere would be raised to 260 atmospheres--so great is the quantity of water on Earth. But in the atmosphere of Venus, it's negligible. There is no definite answer as yet to the question where the water could have disappeared.

Studies of Venus have shown there is a great diversity of gases in the atmosphere. Data on the isotope composition of inert argon gas was a scientific sensation, as well as the discovery of chlorine in cloud layer aerosoles.

The question of how some of the smaller components of the atmosphere are formed came about as a result of more comprehensive knowledge of the atmosphere's composition. It can be assumed, that their origin is tied to the electrical discharges in the atmosphere. For it is precisely lightning that leads to the formation of ozone, nitrogen oxides and even cyanogen in the troposphere of Earth. To locate Venusian lightning, instruments that register electric discharges were installed in "Venera-11 and -12". With their help it was possible to record numerous electromagnetic pulses. Almost at the same time--nine days after the instruments landed--similar pulses were recorded by the American orbital device "Pioneer-Venus".

Further events in the research on electrical phenomena in the atmosphere of Venus developed as in a detective movie. It seemed natural that lightning should originate in the clouds. However, measurements from the "Veneras" indicated that they were rather generated by some comparatively small object. Assuming that this was a distant storm, we had to assume that Venusian storms generate dozens of times more lightning than storms on Earth. The brightness of the night clouds illuminated by lightning was calculated and reports about the stormy spectacle on Venus appeared in foreign journals. Soon, one Soviet scientist announced that as early as 1975 he was able to register flashes of lightning via one of the artificial satellites of Venus. A number of theoretical works about the development of electrical phenomena on Venus were published later.

The "Pioneer-Venus" device was especially reprogrammed and for several months sought the flashes of light on the dark side of the planet. As strange as it may seem, they did not appear, although the radio equipment of the device continued to receive characteristic "crackles" of Venusian lightning. Something was amiss.

At the same time, strange reports appeared that four small American lander devices, descending in various regions of Venus tens of thousands kilometers apart from each other, at the same height of 12.5 kilometers were partially damaged by phenomena of an unknown nature, more than likely of electric origin. May I remind you, that the lower boundary of the clouds is located at a height of 49 kilometers. And if the electrical discharge is generated in the clouds, then apparently it is unable to break through the thirty-kilometer thick layer of atmosphere. The analysis of the Soviet lander's radiosignal showed, however, that transit through approximately these same altitudes was accompanied by unusual phenomena that resembled passing through a layer of plasma.

Soon the concept of "lightning in the cloud layer" was attacked from one more position. Calculations showed that the atlitude dependence of the observed field of electrical discharges corresponds more to the position of a source lower than 30 kilometers, rather than one in the cloud layer.

Thus, it appeared that the phenomena are closer to "a bolt of lightning on a clear day"--lightning originating without clouds.

If all these events had occurred four years ago, they would have remained riddles. But thanks to a substantial progress in planetary radar in the USSR and the United States, and also due to measurements taken by the spacecraft "Pioneer-Venus", a relief map of Venus' salient features appeared. It was the conclusion of experts that it is very much unlike a terrain map of Earth. Most of Venus is covered by hilly plains, and the regions with elevations, resembling continents on Earth, represent a total territory close in size to that of Australia. Some of the elevations very much resemble volcanic masses on Earth. Such a region is Beta, which experts consider a shield-type volcano. The diameter of this formation is about one thousand kilometers. The analysis of gravitational anomalies in this region shows that, in geologic terms, Beta is a young formation. Also on the equator, eight thousand kilometers to the west, at the eastern point of Aphrodite's Land, another such formation was found.

The regions above which the electromagnetic discharges were being registered were compared with the aid of the terrain map. It turned out that the pulses occurred precisely near the volcanic formations. At first, such a connection appeared not very conclusive to the experts. But as the number of observations grew, the concentration of discharges near the volcanic regions became almost certain.

What does such a coincidence mean? Let us turn to known phenomena on Earth.

In 1975, during the mighty eruption of Tolbachik on Kamchatka, a great number of lightning bolts flashed near the volcano's funnel and the pillar of vapor and dust. They were especially powerful, witnesses noted, during the eruption on the island of Saint Helen. (It will be apropos here to remind the reader of the picture by Br'yullov, "The Last Day of Pompeii", where the sky is striped with lightning). All the more, eruptions on Venus should be accompanied by strong and frequent discharges due to the extreme thickness of the atmosphere and the significant electrification of the eruption products.

And what conclusions, on the basis of panoramas transmitted from Venus, can be made about the nature of the region being studied?

In 1975, the Soviet spacecraft "Venera-9" and "Venera-10" landed near the eastern slope of the Beta formation. High resolution radar imaging indicated volcanic formations on the peaks, and in one of the first panoramas scientists found undeniable traces of tectonic activity--rock fragment talus on the slope. In 1978, "Venera-11" and "Venera-12" landed somewhat more to the south, near the eastern point of the Phoebe formation, a close southern neighbor of Beta. Instruments registered numerous electrical discharges in this region. And finally, a little more to the east, "Venera-13" made a landing. The instruments once again registered many electromagnetic pulses, the amplitude of which was greater than in 1978. It is possible that this can be explained by the proximity of the source of the discharges.

Geologists classify the entire Beta-Phoebe area as a volcanic region. In the color panoramas the soil at the landing site has an unusual yellow-brown hue, but this coloration is principally determined by the properties of the atmosphere, which does not permit passage of blue light to the surface of the planet. The microrelief of the surface shows a combination of large chunks of primary rock with loose topsoil covered by a baked-on crust which was broken during the landing of the instrument. The loose topsoil is perhaps the chemically weathered result of past volcanic eruptions. Judging by the low density and the data from x-ray fluorescence analysis, experts have already determined its nature, which one again is connected to volcanic eruptions.

As far as we know, young volcanoes often occur near ancient volcanic formations; there is little doubt presently that the electromagentic pulses being received are more than likely related to current volcanic activity of Venus.

It is the conclusion of geologists that the crust of Venus may be markedly different from that of the Earth. An opinion was even expressed, that the crust of Earth was in a similar state approximately three billion years ago.

Volcanoes eject great quantities of carbon dioxide, water, sulphur, compounds of chlorine, fluorine and other substances into the atmosphere. An analysis of the micro-elements of the atmosphere of Venus conducted by Soviet instruments that have just recently been on the planet, is acquiring a new significance. For example, in 1978-79, significant differences in opinions arose on data transmitted by Soviet and American instruments regarding concentrations of some of the gases. In principle, this can be explained by lesser or greater localized pollution of the atmosphere by volcanic eruptions.

The contribution of Soviet science to the study of the nature of the mysterious Venus, whose surface is eternally hidden from us by clouds, is immense. Her unique character is becoming more perceivable. Instead of Earth's twin, Venus has become her sister. At first there seemed to be not much resemblance between them; now, perhaps, we may view her as our younger sister.

9875
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DEVELOPMENT OF DESIGN FOR 'VENERA' LANDERS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 12 Mar 82 p 4

[Article by V. Zubkov: "At the Building Berth of Star Ships"]

[Text] In a large assembly department the territory of which would encompass more than one hockey rink, there's a special room behind a glass partition. On ingenious supports here stands a lander--a copy of those which landed on Venus just days ago. Nearby is a spherical fairing, the multi-layer construction of which doesn't appear at all massive. But its "forehead" has to withstand a pressure of 300 tons upon entry into the atmosphere.

As the launching of "Venera-4" was being readied, the engineers asked the planetology specialists a natural question: what's the pressure on the planet? "From one to one hundred atmosphere," they replied--tells us one of the creators of the automatic stations, V. Ishevskiy, doctor of technical sciences; "So we designed a device to withstand ten atmospheres. It was destroyed having withstood eighteen. The next stations, "Venera-5 and -6" were designed to withstand eighteen atmospheres but they withstood twenty-eight. Quite literally, we approached by grope-and-feel the design that accomplished a soft landing on Venus..."

The current descent vehicle is a most curious item. At first, experts thought that from the point of view of aerodynamics this ungainly creature was absurd, unable to descend smoothly. In general, they were right. In one of the laboratories I observed how the lander was being tested in a wind-tunnel. The device spun, jerked, and would have tumbled too, if that was in its power. In a word, it seemed as if a smooth landing was out of question. But then, it was dressed in a "skirt", the notched edges of which we saw in the panorama of Venus. It was this skirt that permitted the lander to maintain an enviable stability.

I was shown an entire collection of such "skirts" or, as they're called here, "notched crowns". All of them are of varying design, from which the most suitable was chosen. And after the choice was made, a lot more than one or two models of the lander were dropped from a helicopter. These were turned into scrap in order for their duplicates to successfully complete a landing on the distant planet.

After wind-tunnel tests of the model, we chatted with the well-known Soviet scientist-aerodynamics specialist, Yu. Ryzhov, corresponding member of the USSR Academy of Sciences.

"The most recent program of Venus research has forced a broadening of the entire spectrum of scientific and service equipment aboard the "Venera-13 and -14"landers," Yuriy Alekseyevich stated. And this has brought about more exacting demands for accuracy of movement in the planet's atmosphere. As we know, the information from the lander was transmitted to Earth through the automatic station remaining in space. But the placement of new equipment aboard the most recent "Venera" landers; in particular, a soil sampling device, an instrument to determine the physio-mechanical properties of the soil and others, complicated the already complex aerodynamic form. In addition, atmospheric parameters were also to be measured during descent. For this reason, the instrument could not travel faster or slower than the values it was calibrated for. Moreover, its oscillation in the vertical plane could not exceed 15 degrees. Also, the device could not rotate a great deal. How could all these requirements be fulfilled under conditions of strong gusting wind, and under turbulent atmospheric conditions without relying on heavy fairings? Undoubtedly, their weight would have caused the elimination of several pieces of equipment and this would have diminished the amount of scientific data from the entire expedition.

Traditional methods did not permit assurance of the craft's stability. Concern was expressed that, if the problem could not be solved, a portion of the new equipment would have to be removed. After lengthy research on the flow characteristics of the craft, and a study of the effect of every superstructure, it was decided to emplace the "notched crown". The idea is simple. Every extending part of the lander creates its own current of turbulent flow. The "crown" on the other hand, provides an overall disruption of the turbulence flow in which the individual disturbances are "submerged". However, it was not enough to solve the problem--evidence was also required that it would cause no negative effects in the Venusian atmosphere. And this meant new tests--new wind-tunnel tests, more drops from the helicopter. In a word, it was a very time-consuming and complex operation. But it was richly compensated by the successful landings of Soviet stations in the surface of Venus.

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CSO: 1866/69

PRESS CONFERENCE ON ACCOMPLISHMENTS OF 'VENERA-13' AND 'VENERA-14'

Moscow IZVESTIYA in Russian 14 Mar 82 p 2

[Article by TASS: "The Cosmic Heights of Science"]

> [Text] Press conference dedicated to completion of a new stage in the study of Venus.

The first working year that has passed for the nation since the 26th CPSU Congress was crowned by an outstanding success of Soviet science and technology. Two interplanetary station landers which successfully completed a landing on the surface of Venus on 1 and 5 March, transmitted a wide range of unique scientific information to Earth. In Moscow on 12 March, there was a press conference at the USSR Ministry of Foreign Affairs press center for Soviet and foreign journalists, dedicated to the brilliant contribution of Soviet scientists and engineers in the annuals of space research.

The press conference was opened by the chief of the USSR Ministry of Foreign Affairs press department, Yu. N. Chernyakov.

In his introductory statement, V. A. Kotel'nikov, vice president of the USSR Academy of Sciences, told of some of the planet's features that had attracted the attention of scientists for decades. He underlined that after a successful descent of the scientific devices, the "Venera-13" and "Venera-12" automatic stations are continuing research, orbiting like two artificial satellites of the Solar system. Aboard them, research is being performed in part with the aid of scientific devices manufactured by French and Austrian specialists.

Any soft landing on another heavenly body is an intricate problem in its technical and engineering decisions. V. Ye. Ishevskiy, doctor of technical sciences, one of the managers of the development of the interplanetary stations, told the journalists about the design of the new "Venera's" and the principles of operation of the scientific equipment. In particular, he concentrated in some detail on the design of the lander device. It is a sphere constructed of highly durable materials with a heat-protective layer, inside of which the landing device and a two-stage parachute system are located. The sheath is necessary in the atmosphere of the planet in order to decrease the velocity of the device from escape velocity, which represents 11.2 kilometers per second, to approximately 300 meters per second, the speed required to activate the parachute system.

The spherical sheath is also intended to protect the lander from the effects of dynamic pressure and the high temperatures that occur during aerodynamic braking. The sphere experiences aerodynamic pressures of several hundred tons at this time. The g-loads affecting all elements of the lander exceed their Earth-weight more than 150 times, while the heat load caused by the effect of the plasma comprises ten thousand plus degrees.

The experimental program on the surface of Venus was fully accomplished. The successful realization of the difficult task of taking soil samples on the surface, transmission of clear landscape panoramas at the landing site in black and white and color, the assurance of high reliability of all systems and equipment--all this was achieved thanks to the wide-ranging research of scientists in academic and technical-research institutes. The talents and huge efforts of large collectives of designers, workers, and test-engineers went into this success.

Academician R. Z. Sagdeyev, director of the Institute of Space Research told of the complex research conducted by the two landers in both the atmosphere and on the surface of Venus. In particular, he devoted time to original research methods of the planet that were first suggested by Soviet scientists and implemented on the "Venera" type stations.

The scientist underlined that the scientific work of the stations was already initiated during the Earth-to-Venus journey. Operating here were several scientific devices, including equipment to measure gamma-ray bursts (two experiments--one Soviet-French, the second--Soviet), a magnetometer (Austrian-made), equipment for measuring cosmic rays. Already in the first four months of the flight more than twenty gamma-ray bursts were registered.

With each day, the stations will be moving a greater distance away from Earth. The equipment is functioning well and is registering numerous phenomena, from which it must be ascertained which have been caused by solar flares and which by cosmic objects. As a result, phenomena which are a consequence of processes in neutron stars will be selected for further detailed analysis.

Research on the chemical composition of the atmosphere was conducted with the aid of four different devices. We now have data on the isotope composition of four inert gases--neon, argon, krypton, and xenon. Their relative concentration is very small--it is in the range of one hundred-thousandths to one-hundredths of a per cent, but the scientific significance of these data is quite large. A majority of inert gas isotopes are in a category of so-called relic isotopes, i. e., those that have been preserved without change since the time the atmosphere was formed. Their relative and absolute quantities are therefore an important control parameter for "scrapping" different variants or, as they are sometimes called, "scenarios", according to which the formation of the atmosphere could have occurred.

Aided by a hydrometer, it is very interesting to compare new data about composition of water in the atmosphere with the results on water content in the Venusian atmosphere determined by optical spectrometer and gas chromatograph. This permits achievement of reliable data for the still debated issue of the composition of water vapor along the entire vertical profile of the atmosphere.

The next speaker was V. L. Barsukov, director of the Institute of Geochemistry and Analytic Chemistry, USSR Academy of Sciences, and corresponding member of the USSR Academy of Sciences, who was one of the leaders of the scientific exploration program. Without knowing the past, he stated, it is difficult to look into the future, and thus into the fate of humanity, since the intensity of development of the biosphere is directly tied to the intensity of internal magmatic and tectonic activity of the planet itself, whose time-table and character of activity is established during the first stages of its formation and evolution.

This is why Soviet scientists have been conducting with such persistence a sequential, systematic study of Earth-type planets, with special attention to Venus, the most complex and at the same time, the closest to our planet Earth in terms of structure and history of development.

On the stations "Venera-13" and "Venera-14", in addition to the qualitatively new and sophisticated experiments for determining the physical characteristics of the clouds and the chemical and isotope composition of the Venusian atmosphere mentioned by R. Z. Sagdeyev, three more fundamentally important issues were being studied: the direct determination of the chemical composition of cloud layer aerosols, the direct determination of the soil composition of Venus and transmission of black and white and color panoramas of the surface to Earth.

All these three problems were successfully resolved. In addition, the information that was received from the surface of Venus, both the results from determination of the element composition of soil and the information in the panoramas, makes possible fuller and more definite conclusions about the character and conditions of the geologic processes that have occurred on Venus than if these issues had been studied separately.

But let us return to the cloud layer that thickly covers Venus, denying us the opportunity of Earth-based observations of her surface. We know that the might 20-kilometer cloud layer of Venus is found in the 67-48 kilometer interval of altitude, and has a three-tier structure. Above the cloud layer--up to 8 kilometers--and below it--down to 14 kilometers--a rarified cloudy haze has been observed. On the basis of preceding explorations we also know that the clouds consist of spherical fluid droplets and crystals measured in microns. But we still don't know the most important fact: of what substance do these micro-droplets and little crystals consist, what is their chemical composition. Attempts have been undertaken by previous stations to answer this question , but reliable results were achieved only now thanks to more refined equipment.

The scientist went on to describe the principal new experiments--receiving a color panorama of the surface of Venus and determining the chemical composition of her soil types. First of all, he noted, it's easy to see that the overall appearance at the landing sites of "Venera-13" and "Venera-14" differs significantly. In general, the character of the landscape in the environs of the "Venera-13" landing site resembles lava flows that had undergone noticeable chemical weathering.

And finally, the first color portrait of Venus. When one looks at the color panorama of this planet's surface the first impression is the unreal quality of the colors and the entire color spectrum. But this only appears to be a non-conformity. We see this panorama in colors we would have seen if we were looking out of the lander's porthole. We would have seen these predominantly yellow-orange, greenish colors in any of the objects on the surface, the orange sky and clouds of the same color overhead. This is due to the fact that the blue portion of the spectrum is absorbed at the upper level of the Venusian atmosphere, and unlike on Earth, which is illuminated by white light, her surface and lower part of the atmosphere are illuminated by yellow light with orange-greenish hues. Such are the laws of optics.

One of the main goals of the automatic stations was to determine the soil type at the landing sites. For this, X-ray fluorescence spectrometry equipment was utilized. At present, preliminary data have been received on the content of potassium, magnesium, silicon, aluminum, calcium, titanium, manganese and iron in the selected samples of soil from the landing sites. Further study is continuing on spectrum measurements with the goal of obtaining data on elements that are contained in much lower concentrations--sulphur, chlorine, fluorine, and also elements heavier than iron.

The chemical composition data of the soil that has been received indicates that in the landing area of "Venera-13" soil is present which is classified as leucitic basalt that has undergone chemical weathering. This is a type of deep-seated basalt-composition rock with a high potassium and manganese content found rarely on Earth, primarily in the Mediterranean volcanic region. The soil composition in the landing site of "Venera-14" corresponds to the composition of oceanic tholeitic basalt, which is widely distributed on Earth. And here too, an invaluable service for making a correct interpretation of received data is provided to us by the panorama that permits us to see these soils and the manner in which they are deposited. The absence of secondary changes in the soil speaks of their young age, and the fact there are volcanic eruptions on Venus attests to the presence of noticeable quantities of water in the magma, and at once places in doubt the original assumption that Venus was poor in such a major component. This points us to the need to seek another explanation for lack of water in the atmosphere.

Overall, concluded the scientist, the successful operation of the "Venera-13" and "Venera-14" stations is a large step toward solving the riddles of one of the most mysterious planets, and it represents a significant contribution of Soviet science into the world repository of knowledge.

Afterwards, scientists and experts responded to numerous questions of journalists.

9875
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LIFE SCIENCES

MEDICAL-BIOLOGICAL INVESTIGATIONS UNDER SPACE CONDITIONS--PRESENT AND FUTURE SIGNIFICANCE

East Berlin ZEITSCHRIFT FUER MILITAERMEDIZIN in German No 2, Apr 81
(manuscript received 2 Dec 80) pp 51-52

[Article by Col and Senior Medical Counsellor Professor Dr Sc Med H. Fritze]

[Text] (Over the past 20 years of manned space flight, based on the classification by Gazenko (1971), the initially rather short flights were gradually extended to flights of medium duration. The results of medical-biological investigations indisputably constituted an essential prerequisite for this development in terms of the dialectical interconnection between the procurement of results and the duration of flights. Much attention was devoted to these investigations by scientists in the socialist countries which since 1967 participated in the INTERCOSMOS program. The numerous medical and biological investigations by the international crews and on the Cosmos biosatellites 605, 609, 782, 936, and 1129 are a visible expression of this.)

Medical-biological investigations start with those facts which act upon man during manned space flight. They can be broken down as follows:

1. Those which are conditioned by the physical laws of outer space, such as cosmic radiation, vacuum, and temperature extremes;

2. Those which are based on the dynamics of space flight, such as overloads during the liftoff and landing phases, weightlessness, noise, and vibrations; and

3. Those which are connected with the life and work of man in a limited enclosed space with an artificial atmosphere, such as isolation and absence of social contacts, hypokinesia, neuro-emotional stress, coexistence and cooperation of crew members.

Weightlessness and cosmic radiation are of special relevance here, in other words, the artificial environment with the special features of life and work as well as the neuro-emotional stresses. The significance of medical, psychological, and biological research during the distances covered as of now in space flight can be summarized below; here we must start with the idea that the particular level of knowledge and discovery guaranteed the tackling and accomplishment of current tasks assigned to manned space flights as well as the necessary lead time for their continual pursuit.

As a result of the research activities it was possible further to perfect the system of selecting cosmonauts [astronauts] and to increase the reliability of information and forecasts regarding the preservation of health and efficiency during longer-lasting flights.

The methods and measures connected with medical and psychological preparation and selection of crew members for manned space flights are distinguished by higher effectiveness.

During the flights and while out in the open in space it was possible constantly to improve the methods and their engineering and equipment prerequisites for medical and psychological care and backup support as well as the entire system for the preservation of health and efficiency. As the longer-lasting flights in recent years proved, this effort achieved the required effectiveness regarding adaptation to the factors and conditions of space flight as well as the reliability of the cosmonaut in terms of his function as an operator throughout the entire flight.

An identical result can be reported for medical and psychological backup support after completion of flights during normalization of the reversibly altered physiological functions and the structural deviations.

Cooperation with the pertinent scientific disciplines in the development and assurance of environmental and living conditions in spaceships and space stations--serving the preservation of life, health, and efficiency--are being developed successfully.

The development of equipment, instruments, and resources for protection against the effects of extreme factors cannot be separated from this result of the cooperative effort. As an example we might mention the various types of space helmets, the "Pingvin" space suit, the "Chibis" pressure unit, the treadmill, and the bicycle ergometer. Equipment of this kind enables us not only to meet protective functions and accomplish tasks connected with functional diagnosis but is also used for training and conditioning.

Another result of interdisciplinary cooperation is the creation of various types of simulators for cosmonaut training in preparation of space flights.

As a result of research to provide protection against extreme factors we might mention the names and measures which guarantee safety during exposure to various types of cosmic radiation. It has so far been possible to achieve the required safety during all manned space flights.

In the field of space psychology, reliable diagnosis of professional and psychological adaptation to stresses was created in the context of medical-psychological backup support both during the preparatory period and during longer-lasting space flights.

Last but not least we come to the significance of scientific work done so far in the development of methods and instruments for medical, psychological, and biological investigations under laboratory and simulated conditions and on board outer space vehicles. Here it is interesting to note that a series of instruments is being used also in other medical fields. This applies also to the use of knowledge obtained from research conducted under the heading of space medicine and psychology as well as biology.

The 13th Conference of the permanent study group on space biology and medicine of the socialist countries as part of the INTERCOSMOS program provided an outlook as to further research work during the coming years. In addition to the continuation of scientific work on problems already mentioned, research is aimed at procuring more knowledge on the reciprocal interaction between environmental and flight factors and human and animal organisms. The emphasis here above all is on such psychological matters as response and regulation, compensation and adaptation, the recognition of functional reserves and the perfection of systems for the preservation of life, health, and efficiency. It is furthermore necessary to work on questions of measurement, of the effects of various types of cosmic radiation on the molecular, cellular, and organic levels, on psychological and mental efficiency, as well as radiation protection. In the area of cosmic psychology, questions of optimizing the professional activities of the cosmonauts, increasing their reliability as operators, as well as psychological problems in small groups during the assignment of crew members to spaceships are of importance.

Finally, the coming tasks include the further development of instruments for scientific investigations, above all the creation of instrument complexes which will guarantee the procurement of more information.

PHOTO CAPTION

[P 52] Model of biosatellite in COSMOS Series.

(One illustration; manned space flight--performance physiology, research, development trend.)

5058
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TWENTY YEARS OF MANNED SPACE FLIGHT FROM THE VIEWPOINT OF SPACE MEDICINE

East Berlin ZEITSCHRIFT FUER MILITAERMEDIZIN in German No 2, Apr 81
(manuscript received 19 Dec 80) pp 52-60

[Article by Col Dr Med H. Haase]

[Text] Just 20 years ago, mankind witnessed one of the biggest scientific-technical events of our century. On 12 April 1961, Soviet citizen Yuriy Alekseyevich Gagarin was the first human being to fly out into space in his spaceship "Vostok," thus opening the era of man's penetration into outer space. The tremendous development of manned space flight, the scientific discoveries resulting from it, and the benefit to the national economy, which can already be measured on a global scale, by far exceeded the boldest predictions of those days and make us even more aware of the epochal significance of the pioneering deed of the 27-year-old communist to a much greater extent than at the "zero" hour of manned space flight. Space research and space travel have taken on fundamental significance for the progress of human knowledge and for the rapid development of the social production forces. No modern socialist industrial country therefore can do without planned cooperation in space research (Fisher and Karer, 8).

Gagarin established new dimensions also for biological and medical science. After man had developed over millions of years under the steady influence of the earth's gravitation and after he had biologically and socially adjusted to this constantly acting force in an optimum fashion, it was now important to explore the laws of human and animal life as well as the laws of the existence of plants in a state of weightlessness and under the influence of other space conditions and to create the prerequisites for man's biological and social existence in extraterrestrial space. This fundamental task could not be accomplished as part of a secondary effort. New biomedical work directions and disciplines as well as space biology and medicine were required for that.

Just as aviation medicine developed at the time when man conquered the high altitudes with flying machines heavier than air, so did the field of space medicine take shape with the advance of man into outer space. Emerging from aviation medicine, space medicine combines the most modern discoveries of physiology, functional diagnosis, measurement value procurement and processing, medical-scientific instrument construction, labor medicine, hygiene, psychology, and other special fields. In spite of their historically short existence, we can already detect the emergence of subspecialization fields in space medicine such as, for example "medical backup support for space flights," "space physiology," "medical selection and examination," "clinical space medicine," "space hygiene," and "space psychology."

Preparation for the First Manned Space Flight

Burnazyan and associates (5) distinguish three phases in the development of space biology and medicine. The first phase was characterized by the preparations for the flight of one man into outer space. In order to guarantee safety for manned space flight from the medical angle, the following prerequisites had to be provided and the following tasks had to be accomplished:

The investigation of the effects of space environment conditions upon man;

The development of life support systems that were fit to be taken out into outer space;

Medical, psychological selection of manned space flight candidates and

Continual surveillance of man's state of health during space flights.

The main problem during that stage was to provide scientific evidence for the safety of human life and health prior to the first flight into outer space. This big assignment was carried out only step by step. First of all it was obvious to generalize the experiences of aviation medicine, especially the knowledge obtained during the study of the effects of extreme environmental factors upon man and animals, and theoretically to extrapolate them for cosmic conditions. Life processes had to be investigated in laboratory experiments under imitated space flight conditions. Animal experiments in real subspace and space flights were an important step.

In order to clear the way for man into outer space, the USSR, between 1949 and 1959, launched 26 vertical takeoff rockets with a total of 52 dogs up to altitudes of 470 km (Burnazyan and associates, 5; Yazdovskiy and associates, 15). In this way it was possible to explore the influence of hypogravitation over a period of time of about 10 minutes upon the more highly developed mammal organism. The flight of the second artificial earth satellite (Sputnik-2, launched on 3 November 1957) assumed basic significance.

The bitch "Laika" was the first higher living thing on a space flight path. With this experiment it was possible to prove that a state of weightlessness lasting a longer period of time (7 days) does not impair the primary bodily functions. In August 1960 and March 1961, another four satellites with dogs on board were placed in an earth orbit from the USSR. They confirmed the results of the prior experiments. This means that we have sufficient evidence for the assumption that life and health in space can be guaranteed for man both during the lift off and the landing phases. American scientists arrived at similar conclusions on the basis of some launches of vertical rockets, one suborbital and one orbital flight with monkeys (Henry and associates, 14).

The First Manned Space Flight

The second phase of space biology and medicine was characterized by short manned space flights. It began with the historical flight by Yu. A. Gagarin (Figure 1).

The goal of this first manned flight into outer space was not only to test the viability of man in space; Gagarin instead had the task of exploring man's work and action capabilities under the conditions of space flight by performing simple activities. He made observations of the earth, the sky, and the on-board systems and made entries in his flight log. Although it was not necessary for him to take food considering the duration of his flight (108 minutes), he did test the consumption of liquid and pasty food from aluminum tubes during the 30 minutes of his flight around the earth. It turned out that food can be consumed also during weightlessness and that the act of swallowing and chewing is not tied to the effect of the earth's gravitation. With his comment: "I ate and drank during weightlessness and everything happened the way we do it on earth," he furthermore to a by no means minor degree determined the direction in the methodology of food consumption in extraterrestrial space and the technology of cosmonaut ration preparation and packaging.

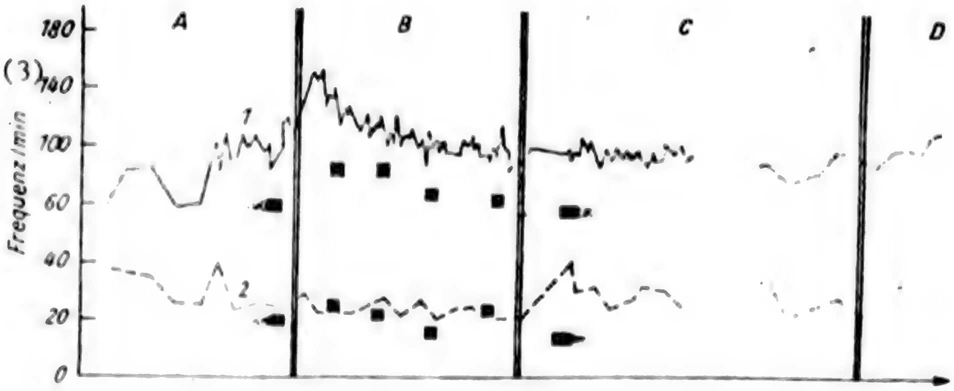

Figure 2. Heart and breathing frequency of Yu. A. Gagarin during various stages of space flight (according to Gazenko and associates, 10). A--Prelaunch period; B--Liftoff phase; C--Orbital flight; D--Landing phase; 1--Heart frequency; 2--Respiration frequency; black squares--dynamics of heart and respiration frequency on centrifuge. Key: 3--Frequency/min.

A biotelemetry system transmitted data on his heart and respiratory activity to the ground (Figure 2). In flight, an air pressure of 750-770 mm Hg prevailed in the spaceship's cabin, with an air temperature of 19-22° C and a relative humidity of 62-71 percent (Aleksandrov and Fedorov, 1). Vestibulo-vegetative phenomena as well as illusions as to his position in space did not develop in Gagarin. Motion coordination remained fully preserved. The first manned space flight proved that man remains capable of working and acting at least during a short period of time in outer space.

But the extension of space flight to several hours already showed that man cannot readily do without the force of the earth's attraction which to a by no means minor degree is necessary for the maintenance of structure and function as well as homeostasis. The attainment of an orbital path within minutes and the transition into the state of weightlessness led to a so far unknown complexity of physical reactions. According to the current state of the art, we can trace them back to the following mechanisms (Gazenko, 9):

Alteration of afferent stimulus influx from peripheral receptors to the CNS as well as interplay of analyzers;

Elimination of hydrostatic pressure in cardiovascular systems and

Absence of weight stress on the supporting and motion apparatus.

We are therefore not surprised that certain changes in the function of the cardiovascular system, respiration (Figure 4), and the vestibular apparatus were observed in the "number 2" cosmonaut who had circled the earth already 17 times (6-7 August 1961) and who was the first man to withstand weightlessness for more than one day (25 hours and 18 minutes). Looking at it from our current viewpoint, these phenomena were "normal" or perhaps even lawful acute adaptation reactions to the state of weightlessness. Titov for the first time reported the problem of "space kinetosis" or space motion sickness. After several more orbits around the earth, he developed vestibular-vegetative disturbances in the form of dizziness, nausea, and illusions as to the position of his body (Gazenko and associates, 10; Komendantov and Kopanev, 18).

By avoiding fast head motions and by assuming a resting position, he was able to bring these phenomena under control. Night-time sleep brought a definite improvement. The cosmonaut himself compared this condition with air sickness.

The practice of manned space flight in the meantime has shown that "space sickness" does appear frequently but also in individually quite differing ways. Out of the 27 Apollo astronauts, eight (Berry, 2) and out of the nine Skylab crew members six (Michel and associates, 24) had kinetosis trouble.

This is why special attention is being devoted to diagnosis of vestibulo-vegetative stability and the training of the vestibular apparatus in the selection and training of cosmonauts.

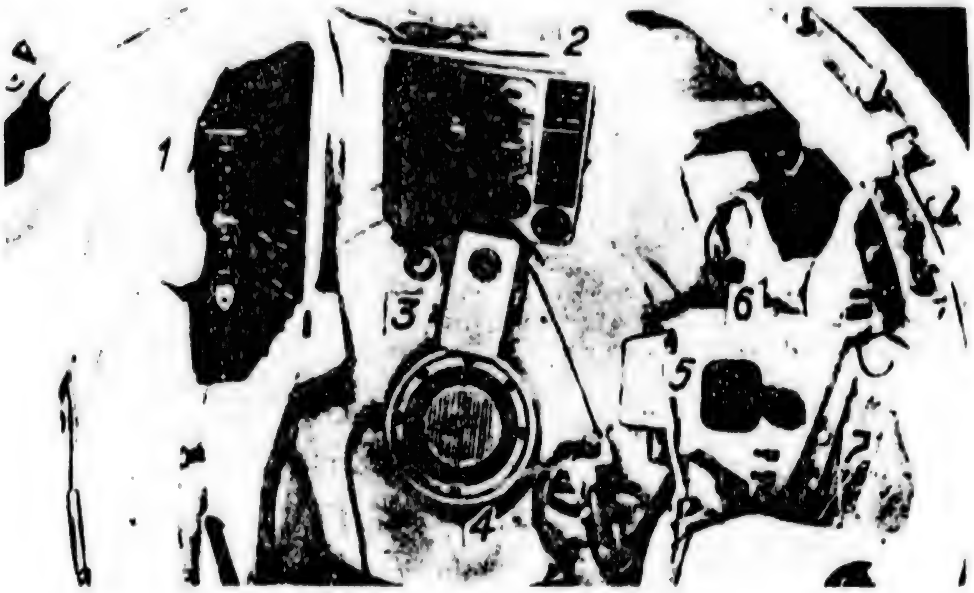

Figure 3. Cabin of spaceship :Vostok." Key: 1--Control desk; 2--Instrument board with globe; 3--TV camera; 4--Porthole; 5--Handle for control of orientation system; 6--Radio receiver; 7--Food container.

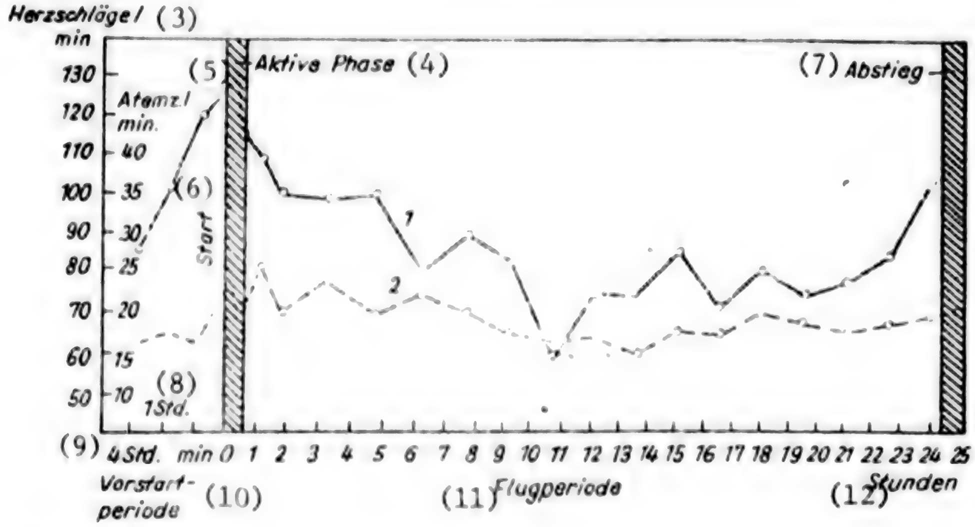

Figure 4. Dynamics of heart and respiratory frequency in Cosmonaut G. S. Titov during 25-hour space flight (according to Gazenko and associates, 10). Key: 1--Heart frequency; 2--Respiration frequency; 3--Heartbeat/min; 4--Active phase; 5--Breaths/min; 6--Liftoff; 7--Letdown; 8--1 hour; 9--4 hours; 10--Prelaunch period; 11--Flight period; 12--Hours.

The main objective of the second manned space flight was to study the influence of weightlessness over a period of several hours on the human organism and on the ability to work and take action. Titov was the first cosmonaut who made motion picture and still photos in outer space and who manually controlled his spaceship repeatedly for more than 1 hour. Most of the time during the flight, he was in the cabin without his helmet on. Titov's flight proved that man remains able to work and act in outer space also over several hours and can sleep in a state of weightlessness.

About half a year after the flight of the second Soviet cosmonaut, the first American went into outer space (Glenn on 20 February 1962). He circled the earth three times. The flight lasted 4 hours and 56 minutes. At that time the cabin temperature rose to 42° C. Because the stabilization system did not function properly, Glenn had to land the capsule manually. The first American space flight confirmed Soviet experiences regarding physical reactions and man's ability to work in outer space. It proved that man can steer the spaceship in case of damage and can guarantee return to earth even under considerable technical difficulties.

The First Woman in Space

The specific reactions of the female organism to space flight conditions were investigated for the first time in the history of space flight during the flight of Tereshkova (16-19 June 1963). The results were compared concurrently with the figures for her male cosmonaut colleague Bykovskiy who was in outer space at the same time; this further enhanced the scientific value of the information obtained. The flight of the two cosmonauts took place under identical conditions. Originally, Tereshkova was to stay in space for 24 hours. But her satisfactory condition and the assured accomplishment of all technical and scientific assignments given to her made it possible to extend the flight period to 3 days. The results of Tereshkova's space flight are significant for the training of additional female cosmonauts as well as the development of special tasks which women will have in the future during the exploration of outer space.

The First Human in Outer Space

Qualitatively new requirements regarding the medical preparation and backup support of manned space flights sprang from man's stepping out into free space. Man's stay and activity outside the spaceship are characterized by the following special features (Glazkov and associates, 12; Borisenko, 4).

1. The absence of any possibilities for the mechanical fixation of the body as well as the wearing of the space helmet (impairment of motor system, especially precision coordination, restriction of information flow from receptors of tactile apparatus) led to new problems relating to the graphic illustration of job functions (Khrunov and associates, 7). To prepare for stepping out into space, it is necessary, parallel to the piloting and surveillance of the spaceship, to carry out a complicated system of successive work operations (putting on and hermeticizing the space helmet, checking the other extravehicular activity equipment, switching of communications facilities, testing the life support systems and other things). These activities must be performed in a very tight space and under considerable psychological and emotional stress. They call for a high degree of attention and stability in handling the cosmic flight factors. During extravehicular activities in outer space, it is necessary to use new methods of specifically goal-oriented

locomotion which can be learned on earth only to a limited extent. Working with the tether cable calls for motor stereotypes which are well developed in terms of stability, plus a high degree of vestibulo-vegetative stability and well-developed optical-motor coordination. Complicated biomechanical skills are necessary for the use of autonomous use of locomotion in outer space. Here it is not only important to find the optimum impulse but also the place for its discharge which will be optimum with relation to the weight center of the body. If these special aspects are not observed, there may be uncontrolled rotary motions, accompanied with a loss of orientation in space and this in turn can bring about a dangerous flight situation.

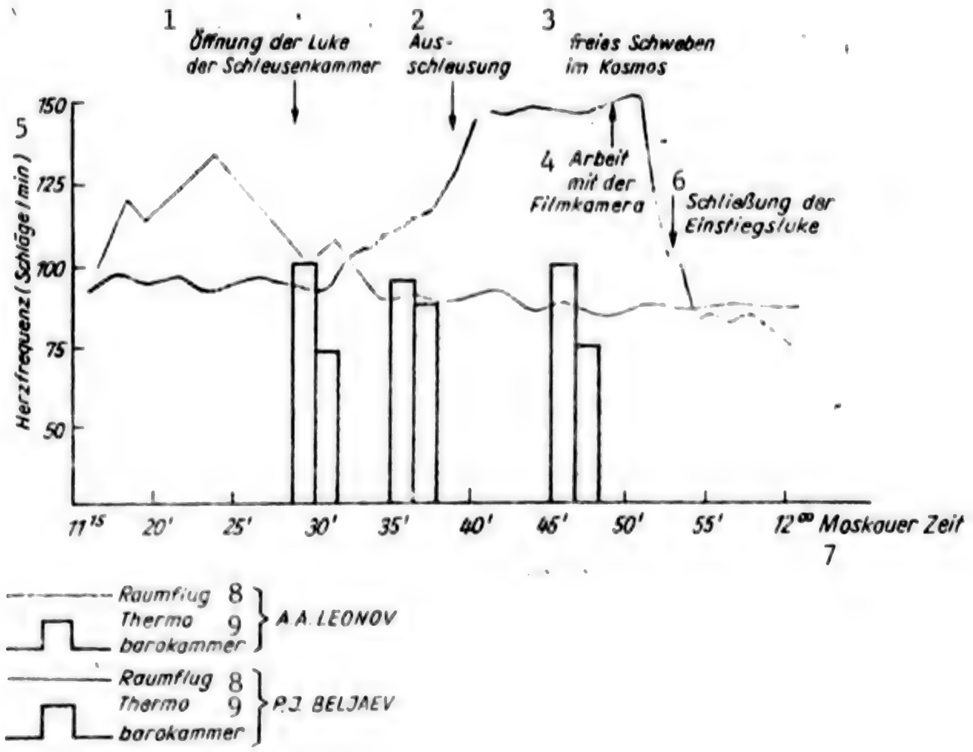

Figure 6. Dynamics of heart frequency in crew of spaceship "Voskhod-2" during extravehicular activities by A. A. Leonov (according to Glazkov and associates, 12). Key: 1--Opening hatch of lock chamber; 2--Exit; 3--Free suspension in space; 4--Working with motion picture camera; 5--Heart frequency (heart beat per minute); 6--Closing the entry hatch; 7--Moscow time; 8--Space flight; 9--Thermo-baro chamber.

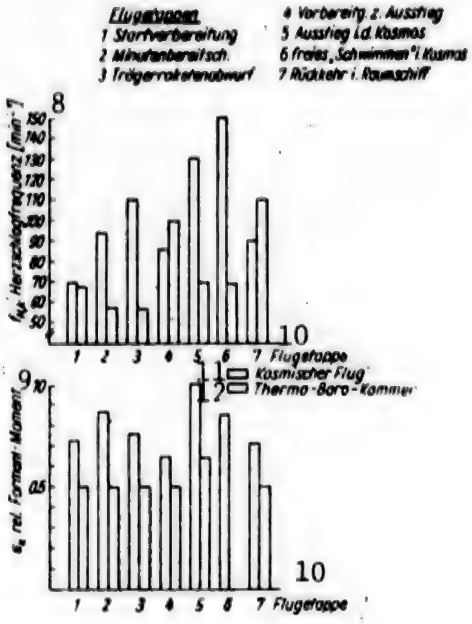

Figure 7. Relative formant factor and heart frequency during various phases of space flight as well as extravehicular activity in A. A. Leonov under simulated and real flying condition (based on Khrunov and associates, 7). Key: 8--Heart beat frequency; 9--Relative formant factor; 10--Flight phase; 11--Space flight; 12--Thermo-baro chamber. Flight phases: 1--Launch preparation; 2--Readiness phase; 3--Booster rocket separation; 4--Preparation for extravehicular activity; 5--Stepping out into space; 6--Free "floating" in cosmos; 7--Return to spaceship.

2. Severe physical stress. It results above all from the accomplishment of work operations under the above-mentioned threshold professional conditions. For flights in spaceships of the "Voskhod" type, the average energy consumption was 460-550 kJ/hr (110-130 kcal/hr); for work in outer space a figure of 2010 kJ/hr (480 kcal/hr) were calculated (Khachaturyants and associates, 6; Waligora and Horrigan, 30; Ketz, 17).

3. Severe emotional stress. Glazkov and associates (12) mention the following as causes of emotional stress in man during extravehicular activity:

The unaccustomed and hostile environment of outer space,

The relatively high risk connected with extravehicular activity,

The feeling of high moral obligation and responsibility for the attainment of the objective,

The shortage of pragmatic information necessary for the accomplishment of tasks and

The discrepancy between the ideas, developing during training and simulation, regarding the absence of any mechanical connection with real sensations.

4. Changes in visual perception. On the basis of outer space myopia (eye adjustment during close-range vision without orientation possibilities) it is difficult

to estimate distances in outer space. Past experience tells us that the distance to a target can be estimated correctly only after 120 m. Because there is almost no reflecting matter in outer space, we cannot rule out difficulties in space perception and shape recognition of objects. Because of the very bright, almost unrefracted light as well as the very sharp formation of shadows, three-dimensional objects can be perceived as flat surfaces. Moreover, the blinding effect complicates the quality of visual perception (Sharpe, 29; Leonov, and Lebedev, 21).

The flight of the spaceship "Voskhod-2" (18-19 March 1965), with Belayev and Leonov as crew members on board, served two objectives (Glazkov and associates, 12), that is:

Experimental testing of design solutions for extravehicular activities and

Investigation of special aspects of psychological-physical state and work ability of the human individual outside the spaceship.

By way of preparation for this flight, it was necessary to examine the biomechanical possibilities of man in a fixationless state and to acquire skills in locomotion and to keep uncontrolled rotary motions and angular positions of the body under control. Training in a simulator was designed to develop the ability to orient the body in outer space with the help of the tether and to stabilize it, to dose the expenditure of force while pushing away from the exit hatch and the traction force on the cable, to learn specifically goal-oriented locomotion and to avoid uncontrolled body positions and motions (Glazkov and associates, 12).

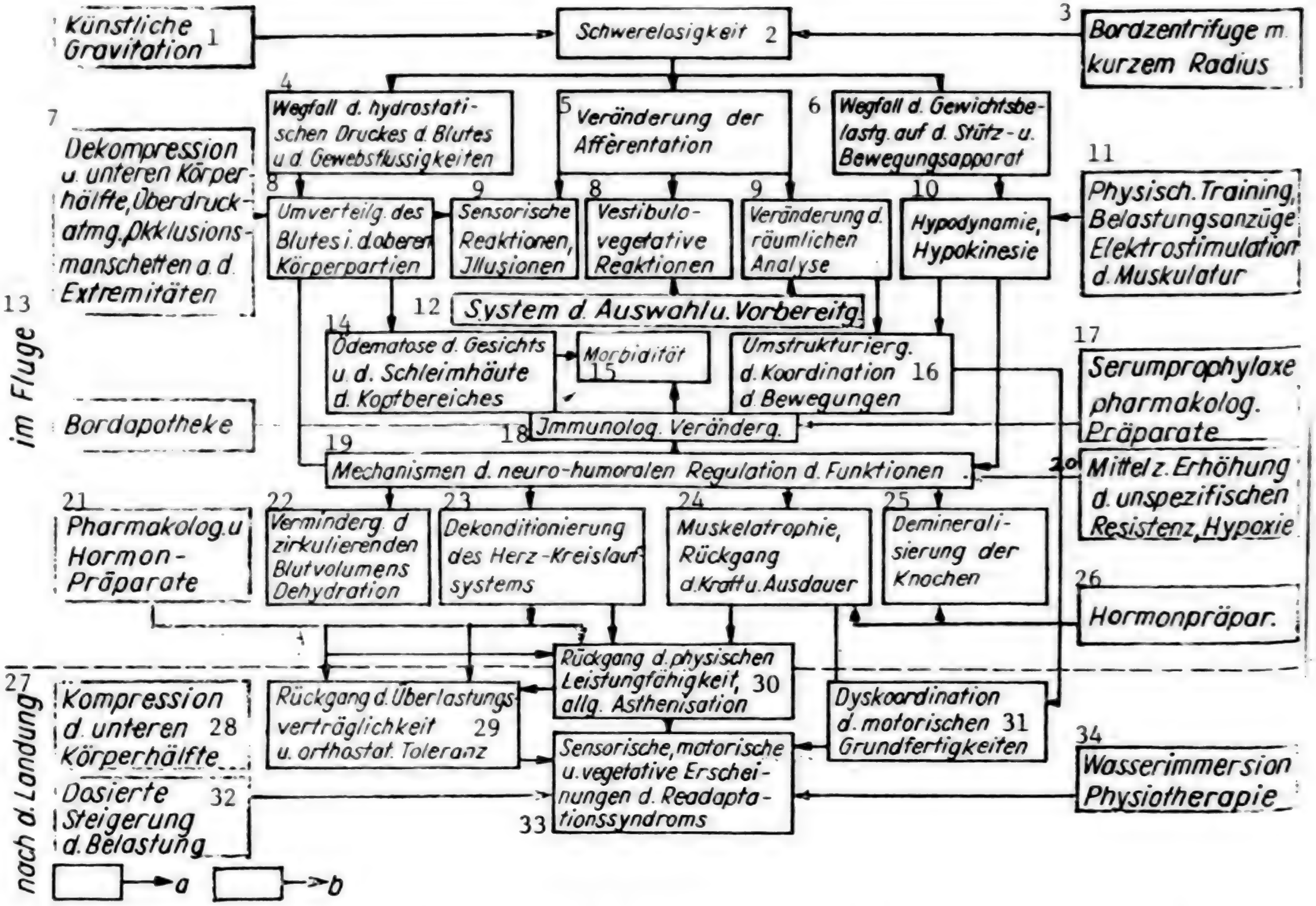
Künstliche Gravitation 1
Schwerelosigkeit 2
3 Bordzentrifuge m. kurzem Radius
4 Wegfall d. hydrostatischen Druckes d. Blutes u. d. Gewebsflussigkeiten
5 Veränderung der Afferentation
6 Wegfall d. Gewichtsbelastg. auf d. Stütz- u. Bewegungsapparat
7 Dekompression u. unteren Körperhälfte, Überdruckatmg. Okklusionsmanschetten a. d. Extremitäten
8 Umverteilg. des Blutes i. d. oberen Körperpartien
9 Sensorische Reaktionen, Illusionen
8 Vestibulo-vegetative Reaktionen
9 Veränderung d. räumlichen Analyse
10 Hypodynamie, Hypokinesie
11 Physisch. Training, Belastungsanzüge Elektrostimulation d. Muskulatur
12 System d. Auswahl u. Vorbereitg.
13 im Fluge
14 Ödematose d. Gesichts u. d. Schleimhäute d. Kopfbereiches
Morbidität 15
Umstrukturierg. d. Koordination 16 d. Bewegungen
17 Serumprophylaxe pharmakolog. Präparate
Bordapotheke
18 Immunolog. Veränderg.
19 Mechanismen d. neuro-humoralen Regulation d. Funktionen
20 Mittel z. Erhöhung d. unspezifischen Resistenz, Hypoxie
21 Pharmakolog. u Hormon-Präparate
22 Verminderg. d zirkulierenden Blutvolumens Dehydration
23 Dekonditionierung des Herz-Kreislaufsystems
24 Muskelatrophie, Rückgang d. Kraft u. Ausdauer
25 Demineralisierung der Knochen
26 Hormonpräpar.
27 nach d. Landung
Kompression d. unteren 28 Körperhälfte
Rückgang d. Überlastungsverträglichkeit 29 u. orthostat. Toleranz
Rückgang d. physischen Leistungfähigkeit, 30 allg. Asthenisation
Dyskoordination d. motorischen 31 Grundfertigkeiten
Dosierte 32 Steigerung d. Belastung
33 Sensorische, motorische u. vegetative Erscheinungen d. Readaptationssyndroms
34 Wasserimmersion Physiotherapie
a
b

Figure 8. Diagram showing pathogenesis of effects of weightlessness on human organisms (a) and preventive possibilities (b) (according to Genin and Pestov, 11; modified by Pestov and Geratewohl, 28). Key: 1--Artificial gravitation; 2--Weightlessness; 3--On board centrifuge with short radius; 4--Elimination of hydrostatic pressure of blood and of tissue fluids; 5-- Afferentation change; 6--Elimination of weight stress on support and motion apparatus; 7--Decompression of lower half of body, overpressure restoration, occlusion cuffs at extremities; 8--Redistribution of blood of upper parts of body; 9--Sensor reactions, illusions; 8--Vestibulo-vegetative reactions; 9--Change in spatial analysis; 10--Hypodynamia, hypokinesia; 11--Physical training, stress suits, electric stimulation of musculature; 12--Selection and preparation system; 13--In flight; 14--Edematosis of face and mucosae in head region; 15--Morbidity; 16--Restructuring of motion coordination; 17--Serum prophylaxis, pharmacological

[key continued on following page]

[key to Figure 8 continued from preceding page]
preparations; 18--Immunological changes; 19--Mechanisms of neuro-humoral regulation of functions; 20--Means for increasing nonspecific resistance, hyposia; 21--Pharmacological and hormone preparations; 22--Reduction of circulating blood volume, dehydration; 23--Deconditioning of cardiovascular system; 24--Muscle atrophy, decline of strength and endurance; 25--Demineralization of bones; 26--Hormone preparations; 27--After landing; 28--Compression of lower body half; 29--Decline in overload tolerance and orthostatic tolerance; 30--Decline in physical performance capability, general asthenization; 31--Dyscoordination of basic motor skills; 32--Dose increase of stress; 33--Sensor, motor, and vegetative phenomena of the readaptation syndrome; 34--Water immersion physiotherapy.

A period of 120 minutes was scheduled for the entire operation (preparation, exit, extravehicular activity, return).

Leonov spent 12 minutes and 9 seconds in outer space (Figure 5). During that time he had to push off from the spaceship three times, he had to perform several turns and twists, and he had to mount a motion picture camera. The individual phases of extravehicular activity were accompanied by different forms of stress. This was expressed among other things by disturbances in the stereotype of the buildup of radio messages, in changes in the span of attention, and in the "forgetting" of individual auxiliary activities that had been programmed (Glazkov and associates, 12). In objective terms, emotional stress was proved on the basis of the heart frequency (Figures 6 and 7) and the relative formant factor during speech analysis (Figure 7) (Glazkov and associates, 12; Khrunov and associates, 7). The diagrams show that both parameters in almost all space flight stages and during extravehicular activity were above the training figures in the thermo-baro chamber; this points to a higher psychological stress under real flight conditions.

After the cosmic pioneering feat of Leonov, man stayed in outer space 36 times. Overall, the cosmonauts spent 11 days, 6 hours, and 21 minutes during extravehicular activities (as of 10 March 1981, including the stay on the moon).

Results of Short-Duration Flights

The main results of the "Vostok," "Voskhod," "Mercury," and "Gemini" was to establish man's action capability during all phases of space flight and during extravehicular activity. Theories regarding the development of pathological disturbances involving the analyzers, the cardiovascular system, the nervous system, and the musculature as well as the metabolism did not turn into reality. Detailed investigations (Kakurin, 16) however showed various functional alterations in the cardiovascular system (fluctuation in heart rate, changes in atrioventricular transmission time, sinus arrhythmia, a few extrasystoles, flattening of the T-wave, reduction in P and R peaks, decline in cardio-pulmonary capacity, and others). Upon return to earth, special characteristics of reduced orthostatic tolerance were rather striking in addition to vestibulo-vegetative systems and a partly impaired spontaneous and voluntary motor system performance. Such indications were observed for the first time in astronauts Schirra and Cooper after "Mercury" flights for a duration of 9 and 34 hours, respectively. They continued up to 19 hours after the landing (Link 23). Disturbances in circulatory system regulation during orthostatic stress with presyncopal states were also observed after the 4-day, 8-day, and 14-day "Gemini" flights (Berry and Catterson, 3). There was also orthostatic dysregulation with delayed readaptation in the crew of "Soyuz-9" whose members in 1970 chalked up a record of 18 days in outer space (Kakurin, 16).

Discoveries Deriving from Longer-Lasting Flights in Space Stations

The third phase of space medicine development is characterized by longer-lasting flights in long-life orbital stations. The first launch of a space station was accomplished in the USSR on 19 April 1971. After the employment of this equipment it was possible on a larger scale to take medical instruments into outer space to check on the state of health and on the prevention of the effects of weightlessness. At the same time, the working and living conditions for the crews were improved. It was possible to counteract hypodynamia by enlarging the working and living quarters.

In this way essential prerequisites were created for the further extension of man's stay in outer space and for the transition to medium-term manned space flight (Gazenko, 9). Soviet space efforts in this way extended the flying time by a factor of "10" during the past 10 years.

The comprehensive biomedical experiments as well as the results of medical care of crew members in the "Salyut" stations led to the following results.

1. Man proved to be very adaptable also in outer space. Adaptation to weightlessness (Figure 8) takes place during the first 7 days with acute phenomena (vestibulovegetative symptoms, illusions as to body position, blood redistribution into the upper parts of the body with feeling of congestion, increased diuresis). After that, wellbeing improved and the adaptation reactions assumed a chronic character (deconditioning of the cardiovascular system, reduction in orthostatic tolerance, inactivity atrophy of skeletal musculature, demineralization of the bone tissue, decline in erythrocyte weight [mass], and others).

2. The adaptation reactions to weightlessness reduce the acceleration tolerance and make readaptation to the earth's gravitation more difficult. This connection is based on the deterioration in the orthostatic tolerance. Changes in the vein tonus (increase in rigidity, decline in elasticity and contractility), above all in the lower extremities, the reduction in the actually circulating blood volume, the decline in the tonus of the leg musculature, as well as the preconditioning of the cardio-pulmonary system are essential causes of orthostatic dysregulations in cosmonauts after space flight. Other readaptation phenomena can be traced back to reactions of the vestibular apparatus as well as changes in motor system performance.

According to the descriptions given by members of the permanent crews of the "Salyut-6" stations, adaptation to weightlessness reportedly is easier and faster than readaptation to the earth's gravitation (Konovalov, 20). The explanation for this observation might be found in the fact that partial effects of weightlessness can be simulated, investigated, and practiced on earth (antiorthostatic training, underwater exercises, parabolic flight, vestibularis training). but that it is utterly impossible to expose the cosmonaut applicants, as part of their training, for example, to 185 days of antiorthostatic hypokinesia and then to the effects of acceleration in the centrifuge. During weightlessness furthermore one can adjust behavior in such a manner that the acute adaptation phenomena can be kept within limits during the first few days (for example, no abrupt head and body motions). For longer-lasting flights, the re-encounter with the effects of gravity, which the individual is no longer used to, constitutes one of the most current medical problems in space travel.

3. To facilitate a return to earth without any danger to the state of health, it is necessary, through suitable preventive methods, to counteract adaptation to weightlessness. Here especially physical training proved suitable. For this purpose, the space stations have various types of training equipment, such as bicycle ergometers (Figure 9), treadmills, and muscle exercise equipment. On flights lasting more than 2 weeks, the cosmonauts must daily train intensively between 2 and 2-1/2 hours. Besides, they wear space suits [stress suits] ("Pingvin" type) which especially provide resistance against the antigravitation musculature. Another method of preventing muscle atrophy consists in galvanic muscle stimulation (Figure 10). To simulate the effect of gravity upon the cardiovascular system during weightlessness ("orthostasis training") the "Chibis" apparatus (Figure 11) is used in space stations. With this device it is possible to simulate the effect of gravitation on blood circulation during weightlessness. The optimization of the work and life system on board plays an essential role in preventing the effects of space flight.

4. One of the most important discoveries deriving from Soviet manned space flights is the confirmation of the correctness of the methodological procedure in preventing the effects of weightlessness. The great effectiveness of preventive methods among other things is expressed by the fact that, in spite of the constant extension of space flights, the cosmonauts return to earth in increasingly better general conditions and that the phase of readaptation to the earth's gravitation can be systematically shortened. For example, in the case of the crew involved in what hitherto has been the longest space flight (Popov and Ryumin, 185 days), there was no decline in the strength of the calf musculature for the first time. These cosmonauts also were the first to return to earth with an increase in their body weight.

5. In case of specifically goal-oriented employment of preventive methods, even a longer stay in a state of weightlessness does not lead to pathological disorders. The changes so far explored in body functions are of a reversible nature. The hitherto longest flight in the history of manned space flight did not produce any contraindications for a further extension of space flight.

6. The further extension of manned space flights however establishes new requirements for medical backup support. Control and surveillance of space crew health must be more intensive. This requires the use of complex diagnostic units and analysis automats in outer space. This is why prerequisites must be created for a continuing analysis of the psychological and emotional state of the cosmonauts in flight. The reliability of the prognosis regarding the medical selection and acceptance, biological stability and operational reliability of cosmic flying personnel must be increased. Besides, it is necessary to achieve rapid adaptation to weightlessness and a further shortening of readaptation to the earth's gravitation. This is why preventive methods must be perfected. That means that

new and complicated scientific problems have to be solved. Some basic functions must be investigated more thoroughly (heat circulation, respiration, oxygen situation, microcirculation, function of analyzers, changes on the cellular and molecular levels).

7. During longer space flights, the psychological factor gains in importance (Myasnikov and associates, 25). To maintain a high degree of work effectiveness and the required psychological and emotional tonus, psychological care for long-time crews is becoming increasingly necessary.

The special features of life in space station (closed cabin, tight living environment, artificial atmosphere, special microclimate, isolation from earth, psychological-emotional stress, circulation of daily routine, cooperation of crew members) can lead to a fatigue phenomena, mood weakening, sleep disturbances, shortage of social contacts, sensory deprivation, and reduction in motivation (Myasnikov and associates, 26). The system of psychological care to satisfy the "new" functional needs which materialized roughly as of the second flying month (need for rhythmical music, confirmation of work results by experts, need for social contacts and others) proved to be effective (Myasnikov and associates, 26).

The programs developed for this purpose for example contain radio and television conversations with well-known personalities in social life, with family members and friends, emotionally positively acting surprise moments (letters, presents), possibilities of using a video and record library on board, replay of TV programs, background music for radio voice communications.

In this way it was possible to achieve a noticeable emotional charge and social activation of long-term crews and an increase in stability as against longer-lasting monotonous life activities (Myasnikov and associates, 26).

8. The longer-lasting Soviet space flights not only led to a considerable further development of knowledge regarding the course and laws of life processes in extraterrestrial space. The control of the individual's biological and psychological state was also achieved to an increasing degree during time spent under the extreme environmental conditions of outer space.

9. The results of space biology and medicine increasingly take effect in the medical care given to the population at large. Although space medicine's primary mission is to guarantee the state of health and work capability of man in outer space and thus (in contrast to other branches of science and specialized fields which are used in outer space) the result primarily is not beneficial to the national economy and popular health, space flight and space medicine research and practice did yield results and discoveries which can be used increasingly also for the health system on earth.

The 12-point program of WHO, regarding the use of space travel, among other things calls for fighting against infectious diseases through early discovery of epidemiological foci from outer space as well as the manufacture of super-pure vaccines in a state of weightlessness. Air pollution as well as the quality of the water reservoir on earth are to be watched by means of IR photography and microwaves from outer space. Telemetry is being used to study urban growth. Satellites are to be used for the rapid transmission of data on epidemiological field studies. The technology of the development of space helmets can be used for the manufacture of protective equipment for work under other extreme environmental conditions. Medical-scientific instrument construction has received strong impetus from space travel. As we know, on-board instruments in spaceships must meet high requirements regarding sturdiness, reliability, and degree of miniaturization. The acceptance of these requirements to no minor degree led to a qualitative improvement also in instruments for medical care used for the population at large. The development of the "Elbe" space audiometer (VEB Praecitronic, Dresden), for the joint USSR/GDR space flight, for example, had an effect in connection with series-produced instruments of a similar type in the form of simplified circuits, material savings, and increased reliability (Grahnert, 13).

Other instruments are being used in a technically modified form for medical care for patients. The American astronauts operated switches and other dials with the so-called "eye switch" on account of the high acceleration forces during liftoff. This design is now used in the medical care given to totally paralyzed persons. In this way the patients are enabled for example to turn the pages of a book, to turn and turn off a radio or TV set, and to steer their wheelchairs (White, 31).

The equipment with which the astronauts simulated walking on the moon is used by patients to relearn walking. The electronic stethoscope, which was developed for the special conditions of space flight, which filters out the noises in aircraft and space stations, proved to be valuable in clinical practice. The foam material, used in cushioning the bucket seats adapted to the individual cosmonauts, proved suitable in decubitus prevention (Whie, 31). As a result of wireless data transmission methods, improved and further developed for use in space travel, it was possible to create a model of medical remote care for groups of persons under extreme environmental conditions which can be transposed to conditions on earth, for example, for the medical supply of population groups in remote regions ("Telemedicine").

On the basis of the close tie-in between aviation medicine and space medicine, as well as the further approach of the two disciplines as a result of the advance of air travel and military aviation into subspace regions, the discoveries of space biology and medicine are used in a particularly broad way for the selection examination, and medical care of flying personnel. That applies for example to questions of prognosis reliability which, in pilot training applicants, is roughly as important as in dealing with applicants for manned space flight. But the use of base-medicine on-board instruments in aircraft as well as telemetry to study the stress on aircraft commanders under realistic conditions might also be mentioned as outstanding examples.

Another point in the WHO program concerns the determination of the limits of physical and psychological performance capability in man. This topic is also of great importance for practical activities in aviation medicine. When it comes to the medical selection of pilot training applicants, the examining physician frequently must answer the question as to whether the particular applicant, with the observed deviation from the state of health--if it does not yet have a pathological value assigned to it--will be capable of withstanding the specific stresses of his future job as aircraft commander. Such decisions are currently still difficult to make because modern medicine knows less about the healthy individual than about the sick individual (Parin, 27). In addition to sports, labor, and aviation medicine, space medicine can be credited with one particular achievement in that it contributed essentially to the reduction and sharper delimitation of the "blank spot" between that which is "normal" and that which is "pathological" and to the enrichment of knowledge about the development of physical functions in the healthy individual under extreme stress. Space biology and medicine particularly explored the life processes under hypokinesia and during the breathing of various gas mixtures. In this way it was possible among other things to obtain clinically valuable discoveries regarding physiological processes during longer periods of bed rest. It was proved that hypokinesia represents not only a state of rest or relaxation but that a restriction of motion activity can also be a considerable stress factor.

Subject of Space Medicine

After a period of 20 years of manned space flight, space medicine can be defined as a scientific discipline whose subject is the protection of health and the guarantee of the life and work capability of man in outer space. Its task includes the following:

Medical-psychological selection and determination of fitness and suitability of cosmonauts;

Medical backup support and control of crew members before, during, and after space flights;

Exploration of the influence of space flight factors on man and his work capability;

Investigations of reciprocal relationships between man, equipment, and environment during space flights;

Medical and psychological preparation of cosmonauts, including performance of or surveillance of general sports and special training activities to increase biological resistance and psychological stability and to develop skills in the operation of life support systems and rescue equipment;

Development of hygienic standards for space vehicles;

Advice during the development and constant perfection of space flight equipment, especially protective equipment and rescue equipment;

Development of recommendations on the continual improvement of working and living conditions on board space vehicles and regarding optimum development of the work and rest schedule;

Investigation of psychological and physiological questions involved in the activity of cosmonauts; and

Creation of scientific foundations for the nutrition of spaceship crew members.

Thus space medicine turns out to be a pronouncedly progressive medical discipline with a predominantly preventive and forward-looking character. Through its co-operation, man was able successfully to extend his work and life sphere into extra-terrestrial space. The 108 minutes of the first orbit around the earth turned into 185 flying days. The living space available to the cosmonauts in the cabin grew from 9 to 300 m^3. So far, 99 cosmonauts or astronauts were in outer space 157 times (as of 10 March 1981). Overall, the space travelers have already spent more than 7 years in outer space. The eighties will open up new bold steps for man into outer space.

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Figure 1. Yu. Gagarin prior to launch into space (photo: Novosti).

Figure 5. Aleksey Leonov, the first man floating in space (photo: TASS [Telegraph Agency of the Soviet Union]).

Figure 9. Bicycle ergometer in "Salyut" space station (photo: Archiv HAASE).

Figure 10. "Tonus" apparatus for galvanic muscle stimulation during space flight (photo: Archiv HAASE).

Figure 11. "Chibis" apparatus for simulation of gravitational effects on blood circulation during weightlessness.

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INITIAL AUDIOMETRIC INVESTIGATIONS IN AN ORBITAL STATION

East Berlin ZEITSCHRIFT FUER MILITAERMEDIZIN in German No 2, Apr 81
(manuscript received 2 Dec 80) pp 60-62

[Article by W. Proehl, R. Mocker, I. Ya. Yakovleva, I. I. Bryanov and M. V. Nefedova, GDR, USSR; the results were published in the magazine HNO-PRAXIS, Leipzig, No 4, 1980, p 257]

[Text] Results of medical-psychological experiments in "Soyuz-29-Salyut-6-Soyuz-31" scientific orbital complex during joint manned space flights, USSR and GDR. Summary. Audiometric investigations were conducted for the first time in an orbital station during the space flights by the cosmonauts Sigmund Jaehn and Valeriy Bykovskiy. The filter audiometer of the "Elbe" type developed for this purpose in the GDR and the precision sound impulse level measuring instrument of the PSI 00024 type, used during audiometric measurements in the station, are described and the audiograms of three measurements by both cosmonauts are described. No major deviations from the norm were found.

1. Introduction

An important area of space medicine involves the investigation of alterations in the basic functions of the human organism under the influence of space flight factors. That also applies to the sensory organs.

We already have voluminous literature (2) on the altered function of the vestibular apparatus under the influence of the space flight factor represented by weightlessness. It was especially the space flight kinetoses that took place and that required intensive scientific work. Questions as to the hearing function of the cosmonauts on the other hand have not been as urgent in past space missions. But in view of long-time space flights they now are increasingly emphasized and they are of practical-scientific significance above all for medical backup support of such flights.

In addition to investigations of hearing during the initial phase of adaptation to weightlessness, in the course of the first 4-5 days, special interest is therefore attached to measurements of the influence of system and radio noises to which the cosmonauts are constantly exposed. On the occasion of space flights by international crews with USSR cosmonauts and a series of crew members from the socialist countries, the "audio" experiment was prepared and conducted for the launching of the GDR cosmonaut jointly with the USSR. Until that time there had been no information on the state of the auditory analyzer and possible alterations during space flight (3).

These initial audiometric investigations in a space station and the sound level measurements were designed to clarify the investigating conditions and to perform a functional test of the special measurement equipment used under the influence of space flight factors as well as the procurement of guiding measurement values. They are to be used as foundation for designing further experiments to determine the influence of weightlessness in combination with noise pressure stresses on the functional state of the auditory analyzer.

2. Methodology

During the docking mission of the Salyut-6 space station with the spaceship Soyuz-31, the crew of Soyuz-31 was to make determinations of the air hose auditory thresholds with a GDR instrument. In order better to be able to judge the hearing thresholds measured, frequency-evaluated sound level determinations had to be performed with a GDR instrument at the audiometry station.

Due to the readiness of the VEB Praecitronic Dresden, and the VEB RFT [Radio and Telecommunications Technology] measurement electronics "Otto Schoen" in Dresden, to cooperate in this effort, it was possible to make the required instruments available. A battery-filter audiometer was quickly developed (Figure 1). The instrument met the high requirements which are established for a space mission especially regarding functional reliability and stability. The special conditions of handling measurement instruments in a state of weightlessness were also taken into consideration in the design phase.

With the help of the "Elbe" audiometer it is possible to determine air hose thresholds in the frequencies of 500, 1,000, 2,000, 3,000, 4,000, and 6,000 Hz in an intensity range from -10 db to +80 db. To be able to restrict the effect of the noise level in the space vehicle upon the audiometric results as much as possible, the dynamic earphones were covered by a sound-proofing cap and the frequency-dependent attenuation effect was determined.

To determine the acoustic conditions in the spaceship during audiometry, the precision-impulse sound-level meter model 00024 and the octave filter model 01 016 were selected and these series instruments were adapted to the higher stability requirements for space flights by VEB "Otto Schoen" measurement electronics (Figure 2).

This study is intended to present the auditory threshold measurement results from the "Audio-1" experiment. An essential restriction regarding possible information content springs from the small data volume. The results therefore can be merely presented and they can be interpreted only with reservations.

The "Audio-1" experiment included the following steps:

Measurement of the linear and A-evaluated sound pressure level and its spectral makeup at the places in the spaceship where audiometry was to be performed;

Determination of air hose auditory threshold in the six audiometer frequencies during stay in the Salyut-6 station;

Investigation of auditory function of crew members before and after space flight.

Each time, two cosmonauts participated in the audiometric measurements both on the ground and on board the space station, with one acting as test subject and the other as investigator. They would switch their roles from time to time.

For organizational reasons, the audiometric investigations of the crew of Soyuz-31 was performed only on one day of its stay in the Salyut-6 station. These measurements were made on the third space flight day in the morning, at 1100, and in the evening, at 2400.

The first investigation was carried out in the linkup passageway section of the spaceship and the second one was carried out in the place where the engineer was sleeping, that is, the GDR cosmonauts.

The auditory threshold determination prior to space flight was performed by the cosmonauts 30 days before. Constant auditory thresholds were measured at that time. The measurements were repeated in the same manner 24 hours after landing.

3. The noises developing at the audiometer stations have a broad frequency spectrum with low-frequency and also high-frequency portions. The overall level roughly corresponds to the noise level norm for spaceships recommended by Uganov (1).

All data on the audiometric investigations conducted by the crew members of the spaceship Soyuz-31 are illustrated in figures 3 and 4. Figures 3 and 4, curve 1, show the average audiograms of the cosmonauts Bykovskiy and Jaehn from three initial investigations. As we can see from Figure 1, curve 1, the auditory thresholds of the right and left ear of cosmonaut Bykovskiy reveal a slight deviation from the values in each frequency investigated and an insignificant auditory threshold drop of 10-15 db and 4,000 - 6,000 Hz compared to adult norms.

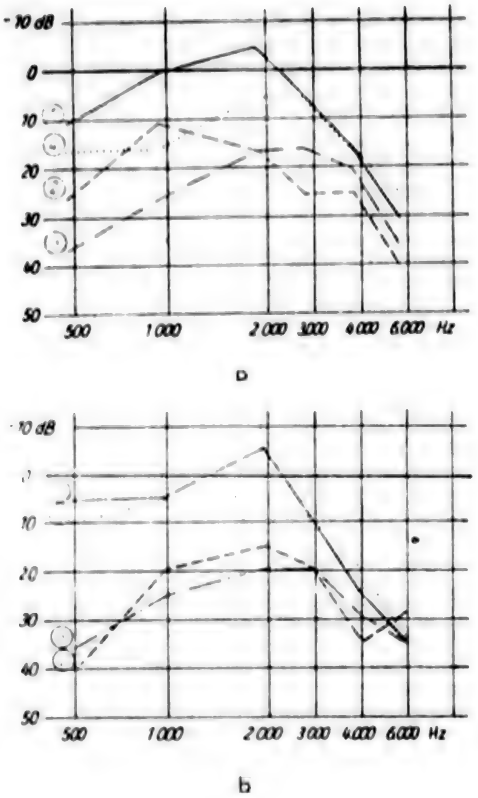

Figure 3. Audiograms of cosmonaut Bykovskiy. (a) Right ear; (b) Left ear; 1--Initial audiogram, 27 July 1978; 2--Audiogram on board of "Salyut-6" on 30 August 1978, 110-; 3--Audiogram on board of "Salyut-6" on 30 August 1978, 2400; 4--Audiogram after landing, 4 September 1978, 1100 local time.

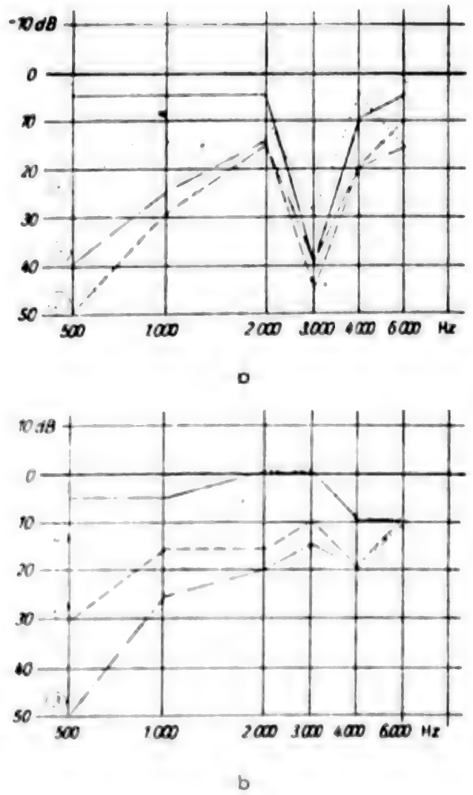

Figure 4. Audiograms of cosmonaut Jaehn, (a) Right ear; (b) Left ear; 1--Initial audiogram, 27 July 1978; 2--Audiogram on board of "Salyut-6" on 30 August 1978, 1100; 3--Audiogram on board of "Salyut-6" on 30 August 1978, 2400; 4--Audiogram after landing, 4 September 1978, 1100 local time.

The auditory thresholds of cosmonaut Jaehn during the initial investigation corresponded to the norm. A certain auditory threshold asymmetry did exist however likewise in the form of a drop of 40 db at 3,000 Hz on the right.

The curves measured on earth clearly differ from the threshold measured in space. This applies above all to the 500-2,000 Hz measurement frequency. Toward the higher frequencies, all curves blend more or less pronouncedly into each other and reveal only accidental deviations within the audiometric measurement error range. The few available data do not enable us to prove any significant differences in the frequencies between 3,000 and 6,000 Hz (use of the U-test; frequencies between 2,000 and 6,000 Hz were calculated).

If we look at the curves in the frequencies in which threshold drops were observed in both cosmonauts during the preflight examination, we cannot detect any noticeable auditory threshold changes there as compared to the initial investigation.

Certain differences relating to the initial measurement also exist in the audiograms prepared 24 hours after landing (curve 4). As we can see in figures 3 and 4, a certain auditory threshold deterioration can be observed in both cosmonauts in the lower frequencies. In the case of Jaehn, that above all concerns the frequency of 500 Hz and in Bykovskiy it involves the frequency of 1,000 Hz on the right ear and the frequencies of 1,000 and 2,000 Hz on the left ear.

The auditory threshold curve measured after landing may be an expression of auditory fatigue which is part of a general psychological and physical fatigue among cosmonauts during the first phase after landing.

4. Conclusion

We can derive five conclusions from the available measurement data:

The identical tendency of the auditory threshold curve, which can be observed in both cosmonauts for the right ear and the left ear, proves that the measurements were made very carefully by them. Such evidence also consists of the faithful reflection of the auditory threshold drop, observed in Jaehn since 1968, in the frequency of 3,000 Hz on the right ear.

Depending upon the type of threshold curve in both cosmonauts, the auditory threshold differences in the lower frequencies between measurements on the ground and on board of Salyut-6 can be traced back to the disturbing influence of the noise level in the orbital station. The reduction in auditory sensitivity after flight and the failure to restore the normal state during the period of 24 hours after landing points to a certain auditory fatigue.

To improve the investigating conditions in the spaceship, we should as much as possible look for even more effective insulation against or reduction of the environmental sound pressure.

The measurement equipment used proved to be fully effective under the stresses of space flight. Hints as to the improvement of operating comfort are being taken into consideration in the continuation of the experiment.

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Figure 1. The "Elbe" audiometer.

Figure 2. The model 00 024 precision impulse sound level meter with 01 016 octave filter.

Figure 5. The two-man crew for the joint USSR-GDR manned space flight (Gorbatko and Koellner) during training for the "audio" experiment.

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INTRACUTANEOUS PARTIAL OXYGEN PRESSURE (pO_{2ic}) IN MAN DURING SHORT-TERM SPACE FLIGHTS --RESULTS OF JOINT USSR-GDR SPACE FLIGHT

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[Article by H. Haase, E. A. Kovalenko, A. Vacek, M. P. Bobrovnitskiy, B. Jarsumbeck and V. N. Sementsov, GDR, Czechoslovakia, USSR]

[Text] Summary. The result of the "Kislorod/Oxygen" experiment, carried out by the third international crew of the "Soyuz-29--Salyut-6--Soyuz-31" scientific orbital complex (Joint USSR-GDR flight), are presented in this article. The partial intracutaneous oxygen pressure ($pO_{2\ ic}$) was determined polarographically. The measurement probe used was an uncovered platinum puncture electrode. In the spaceship engineer, the $pO_{2\ ic}$ during space flight had dropped by 19 mm Hg and local oxygen utilization had gone down by 4 mm Hg. During the hyperventilation test, during the first few days after the space flight, the spaceship commander only had a minor increase while the engineer and no increase in the $pO_{2\ ic}$. The results are preliminary. They agree well with the measurements on other spaceship crews.

1. Introduction

While the mechanisms of external respiration have been adequately explored, we have comparatively little knowledge as yet about the final stage of oxygen transport from the capillaries to the mitochondria. This applies especially to the human organism under the influence of extreme factors. The passage of oxygen from the capillaries into the tissues as we know depends on the partial oxygen pressure gradient (pO_2). The knowledge of the dynamics of partial oxygen pressure in the tissues therefore constitutes an important prerequisite for the evaluation of the oxidation or metabolism processes in the body periphery as well as for the creation of the foundations for defective prevention. One methodological approach for investigating this mechanism--especially also under the effect of cosmic environmental factors--consists in the physical-chemical measurement of the current partial oxygen pressure in the skin ($pO_{2\ ic}$) by means of the puncture electrode.

In animal experiments and by means of human measurements it was possible to show that there is a decline in the peripheral blood flow and a drop in the $pO_{2\ ic}$ as well as the local oxygen utilization volume (3) during the simulation of partial effects of weightlessness, for example, immersion and antiorthostatic hypokinesia. These results led to the assumption that the $pO_{2\ ic}$ in man is likewise reduced during weightlessness, something which might possibly be of importance to the medical backup support for manned space flights. On the basis of this question, a method was adapted for the investigation of the dynamics of $pO_{2\ ic}$ for use in outer space. This study reports on the continuation of past experiments (5, 8, 9) in terms of a case-history contribution on the results of measurements of $pO_{2\ ic}$ in the third international crew of the "Salyut-6" scientific orbital station.

2. Methodology

The investigations were carried out the miniaturized oxymeter (8) which had been specially developed for use in space. The instrument (Figure 1) was developed in cooperation with Soviet specialists in Czechoslovakia and is based on the polarographic principle (4). An uncovered platinum puncture electrode, with a diameter of 30 nm, was used as measurement probe. The anode consists of an Ag/AgCl plate which has a borehole in the middle to receive the coupling medium (Figure 2). It is glued on the skin near the puncture electrode. The measurement electrodes were calibrated prior to use in outer space on the ground with a sulfite solution and a air-saturated physiological common salt solution. Only electrodes with a residual current of less than 1 percent of the oxygen pressure present in the physiological calibration solution were used for the measurements. With the help of a formula, which also considers the temperature gradient of the electrode, absolute pO_2 values in the tissue were calculated (1). After numbering and radiation sterilization, the electrodes were taken along into space (Figure 3). The current intensity measured had to be read off by the cosmonauts and had to be entered into the flight log. Just 5 minutes after the application of the electrodes, the recording of the initial level of the $pO_{2\ ic}$ was begun. Before and after the flight, the dynamics of $pO_{2\ ic}$ were investigated in addition also in connection with hyperventilation (30 seconds) and respiration of pure oxygen (10 minutes after hyperventilation, up to the attainment of the level of the pO_2 curve). As a yardstick for the intensity of the aerobic metabolism processes, the local intracutaneous oxygen utilization (drop of $pO_{2\ ic}$ in mm Hg/min) was determined. For this purpose, the blood supply in the skin was interrupted by means of a clamp directly at the oxygen electrode. The electrodes were recalibrated each time after completion of a measurement. The measurement probes used in outer space were therefore brought back to earth. Because a partial oxygen pressure of 200-204 mm Hg prevails in the orbital station's respiration air, measurements of the $pO_{2\ ic}$ had to be performed during the respiration of a gas mixture corresponding to the cabin atmosphere on earth for comparison purposes.

3. Results and Discussion

The $pO_{2\ ic}$ measured with LP-7 polarograph in the control group (n = 113 with 245 measurements) under laboratory conditions averaged 37.7 ± 0.7 mm Hg.

The investigations using the on-board instrument on 16 test subjects in the same group of subjects (93 measurements) yielded 37.0 ± 0.9 mm Hg. There was thus good agreement of the measurement results between the laboratory instrument and the space oxymeter. In a comparison group of cosmonauts, in 39 measurements using the on-board instruments, an average $pO_{2\ ic}$ 40.1±1.2 mm Hg was measured while breathing air, and 56.0±2.0 mm Hg while breathing a gas mixture corresponding to cabin atmosphere. This finding as well as the higher values found during the breathing of the gas mixture throughout, as well as pure oxygen, can probably be traced back, with reference to the data in the literature (7), to the higher physical training level and the resultant better oxygen supply of the body periphery in the cosmonauts.

The results of the measurement of the $pO_{2\ ic}$ in the third international crew, before during, and after flights are compiled in Table 1 and Figure 4.

Table 1. p[illegible]ic Values in the Third International Crew of the "Salyut-6" Scientific Orbital Station

Untersuchungsbedingungen 1			2 Luftatmung (pO_2 = 150–154 mm Hg)	3 Atmung eines Gasgemisches (pO_2 = 200–204 mm Hg)		4 Atmung reinen Sauerstoffs	6 Hyperventilation 30 s		7 Intrakutane O_2-Utilisation (mm Hg/min)	
							5 max. Anstieg	max. Abfall		
Allgemeine Vergleichsgruppe (93 Messungen) 8			37,0 ± 0,9	49,8 ± 2,2		174,2 ± 8,1	46,5 ± 1,2	33,5 ± 0,9	12,8 ± 0,3	
Kosmonauten-Vergleichsgruppe (39) Messungen) 9			40,1 ± 1,2	56,0 ± 2,0		210,0 ± 11,0	—	—	13,5 ± 0,4	
Bi	10 vor dem Flug	30. Tag 13	36,4	—		260,0	40,9	30,8	12,1	
		20. Tag 14	42,5	56,3		250,0	46,3	36,3	12.1	
	11 während des Fluges	4. Tag 15	—	36,0	$\bar{x}$ = 37,0	—	—	—	—	$\bar{x}$ = 8,6
		5. Tag 16	—	49,4		—	—	—	9,9	
		5. Tag 16	—	25,6		—	—	—	7,3	
	12 nach dem Flug	1. Tag 17	42,0	59,0		300,0	—	—	11,4	$\bar{x}$ = 10,1
		3. Tag 18	44,0	58,0		220,0	44,0	38,0	8,8	
K	10 vor dem Flug	30. Tag 13	33,6	—		—	37,1	29,4	12,2	$\bar{x}$ = 11,9
		20. Tag 14	46,3	67,5		255,0	55,0	42,0	11,6	
	12 nach dem Flug	1. Tag 17	25,2	31,5		66,8	28,4	18,9	7,2	$\bar{x}$ = 8,1
		3. Tag 18	22,6	31,5		90,7	25,2	17,6	9,0	

Key: K--Commander; Bi--On-board engineer; 1--Investigating conditions; 2--Air respiration; 3--Respiration of gas mixture; 4--Breathing pure oxygen; 5--Maximum rise; 6--Maximum drop; 7--Intracutaneous O_2 utilization; 8--General comparison group (93 measurements); 9--Cosmonaut comparison group (39 measurements); 10--Before flight; 11--During flight; 12--After flight; 13--30th day; 14--20th day; 15--4th day; 16--5th day; 17--1st day; 18--Third day.

This shows that the $pO_{2\ ic}$ drops during stay in weightlessness and that local oxygen utilization goes down. Compared to the initial value connected with air respiration of 20th day prior to launch, we observe here a drop of the $pO_{2\ ic}$ by about 5 mm Hg. When breathing the gas mixture, which corresponded to the composition of the space stations' cabin atmosphere, the difference was 19 mm Hg. Local oxygen utilization here had dropped by about 4 mm Hg/min. These results agree with the findings in other spaceship crews (5, 9). On the 4th and 5th flying days, in a total of five cosmonauts so far, an average $pO_{2\ ic}$ of 39.1±3.3 mm Hg was measured and intracutaneous oxygen utilization of 9.1±0.8 mm Hg/min was measured. The mean value for all measurements performed in space so far on a total of eight cosmonauts, not considering the day of flight on which the measurements were made, is 39.4±3.5 mm Hg for the $pO_{2\ ic}$ and 10.2±1.1 mm Hg for intracutaneous oxygen utilization. The lowest individual values determined were 21.6 mm Hg for the $pO_{2\ ic}$ and 6 mm Hg/min for local oxygen utilization during the 32nd day of flight (5).

Although, under conditions of weightlessness, we may assume a change in the ventilation-perfusion ratio, these phenomena would seem to be not so much due to the impairment of the ventilation function of the lungs but rather to chances in microcirculation (among other things, decline in blood flow in capillary bed, opening of arteriovenous anastomoses) as well as a certain tissue edematosis which accompanies the redistribution of blood into the upper half of the body and the increase in the central vein pressure. This is also indicated by the results during weightlessness imitation experiments. Both in case of a 182-day antiorthostatic hypokinesia and during short-time antiorthostatic position for 15-20 minutes with angles of -15° and -30° it was possible to prove a significant drop of the $pO_{2\ ic}$ in the shoulder region. At the same time a definite increase in the blood volume was registered in that region (5).

Initial investigations during long-time flights lead us to assume that a normalization of the pO_{2ic} as well as the local oxygen utilization in the peripheral tissue takes place during the process of adaptation to weightlessness. For example, on the 97th flying day in the commander of a permanent crew of the "Salyut-6" orbital station a pO_{2ic} of 51 mm Hg and local O_2 utilization of 14.6 mm Hg/min was measured while in the case of the on-board engineer at the same time the figures were 57.4 mm Hg and 14.5 mm Hg/min (5). After return to earth, the $pO_{2\ ic}$ and the intracutaneous oxygen utilization are normalized within 2-8 days. In the case of the on-board engineer of the third international spaceship crew, the $pO_{2\ ic}$ was again in the normal range already on the first day after landing with 59.0 mm Hg and had even exceeded the initial values. In the case of the commander, both the $pO_{2\ ic}$ and local oxygen utilization on the third day after landing were still definitely below the initial values.

The hyperventilation test was applied only before and after the flight. In the initial phase, due to an increase in alveolar and arterial oxygen tension [pressure], it leads to an increase in the $pO_{2\ ic}$. This indirectly describes the ventilation capacity of the lungs. As a result of hypokapnia which sets in during the tests and the attendant peripheral vaso-constriction, the $pO_{2\ ic}$ drops at the end of the test in spite of high arterial oxygen pressure. In this way, the vessel reaction to hypokapnia can be judged indirectly. For the further differentiation of this effect, we must resort to the transcutaneous measurement of the $pO_{2\ ic}$ (6, 10, 2).

in the third international spaceship crew, these reactions were clearly pronounced before the flight.

After staying in outer space, the commander revealed only a minor while the engineer revealed no increase in the $pO_{2\ ic}$ at the start of hyperventilation (Table 2). We cannot say on the basis of these investigations what mechanism this finding can be traced back to.

Table 2. Dynamics of $pO_{2\ ic}$ (in mm Hg) in Members of the Third International Crew of the "Salyut-6" Orbital Scientific Station during Hyperventilation Tests for a Period of 30 Seconds and After Space Flight

Zeitpunkt der Untersuchung 1		2 Ausgangswert pO_2 ic	Hyperventilation 30 s (Luftatmung) 3	
			max. Anstieg 4	max. Senkung 5
30. Tag vor dem Flug 6	K	33,6	37,1	29,4
	BI	36,4	40,9	30,8
20. Tag vor dem Flug 7	K	46,3	55,0	42,0
	BI	42,5	46,3	36,3
1. Tag nach dem Flug 8	K	25,2	28,4	18,9
	BI	42,0	—	—
3. Tag nach dem Flug 9	K	22,6	25,2	17,6
	BI	44,0	44,0	38,0

Key: K--Commander; Bi--On-board engineer; 1--Time of investigation; 2--Initial value; 3--Air respiration; 4--Maximum rise; 5--Maximum drop; 6--30th day prior to flight; 7--20th day prior to flight; 8--First day after flight; 9--3rd day after flight.

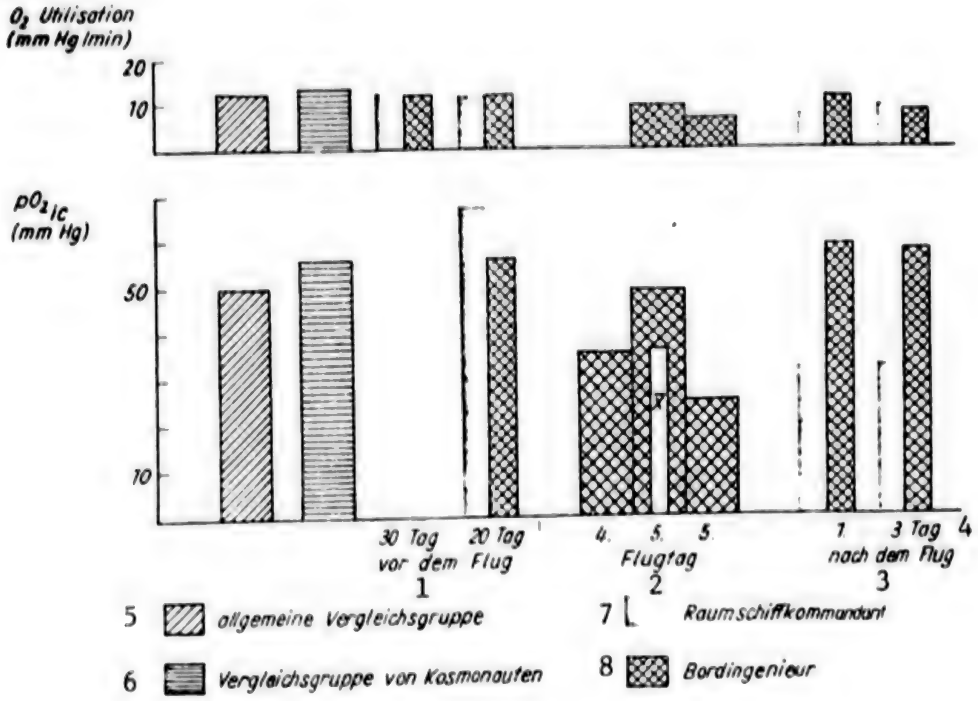

Figure 4. Intracutaneous partial oxygen pressure ($pO_{2\ ic}$) and intracutaneous O_2 utilization in members of the third international crew of the "Soyuz-29--Salyut-6--Soyuz-31" scientific orbital complex. Key: 1--Prior to flight; 2--Flying day; 3--After flight; 4--Day; 5--General comparison group; 6--Comparison group of cosmonauts; 7--Spaceship commander; 8--Engineer.

By way of summary we can say that the results presented agree rather nicely with the results of past space experiments carried out under the name "Kislorod/Oxygen." They reveal a trend toward a decrease in the $pO_{2\ ic}$ as well as local oxygen utilization during weightlessness. This would seem to confirm the initially stated assumption as to the drop of the $pO_{2\ ic}$ during weightlessness. In interpreting the results however it must be kept in mind that it is disputed from the electrochemical viewpoint whether one can give absolute in-vivo values for the $pO_{2\ ic}$ with an in-vitro calibrated and uncovered electrode. The authors are aware of this problem. They nevertheless decided to adopt this procedure on the basis of the consideration that the measurement conditions applied here in good approximation make it possible to calculate the values, measured in nanoamperes, by means of subsequent calibration for comparison purposes as mm Hg pO_2 and to give them as conditionally absolute values. Of course, these results, which cannot yet be backed up statistically are only preliminary. To be able more effectively to solve the problems of life support and maintenance of human action capability in space and to be able to derive conclusions for the development or perfection of preventive means and methods, these investigations would have to be continued and completed in a specifically goal-oriented manner.

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Figure 1. "Oxymeter" instrument used on board for holographic determination of intracutaneous partial oxygen pressure during space flight.

Figure 2. Measurement probe (uncovered platinum puncture electrode, diameter 30 nm) and anode for polarographic determination of intracutaneous partial oxygen pressure during flight.

Figure 3. Pouch for carrying sterilized puncture electrodes and other accessories of oxymeter in space.

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SPACE APPLICATIONS

SOVIET COMMUNICATIONS SATELLITES

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[Introduction and excerpts from book "Communications Satellites", by Pavel Artem'yevich Agadzhanov, doctor of technical sciences and Lenin Prize winner, Amos Aleksandrovich Bol'shoy, doctor of technical sciences and Lenin Prize winner, and Viktor Ivanovich Galkin, candidate of technical sciences, Izdatel'stvo "Znaniye", 28,570 copies, 64 pages]

[Excerpts] Introduction

A characteristic feature of the modern scientific and technical revolution is the steadily growing need for the transfer of large amounts of various kinds of information over long distances. Of course, the amount of information circulating through all kinds of communications channels in a modern industrially developed country is approximately proportional to that country's industrial potential. This is due, in particular, to the extension of industrial communications back and forth and to the rapidly progressing process of the creation of associations based on separate enterprises, which in turn is governed by the existence of a unified combined multisector national economic system.

The intensification of development and the interrelationship and interdependence of the normal functioning of all components of economic activity have brought to the forefront the task of creating in our country appropriate automated control systems utilizing high-efficiency communications and data exchange systems. Telephony, telegraphy, radio broadcasting, television, the transfer of various information and other material from data banks, the exchange of information in large automated control systems and computer networks, the transfer of matrixes for printing newspapers--this is far from a complete list of the problems solved by communications engineering in our time.

The intensely developing integration among nations, and the rapid growth of international communications in production, trade, in the area of culture and scientific research work have caused an annual increase in the flows of information circulating through internal, international and intercontinental communications radio links. Artificial earth satellites (ISZ's) have been playing an ever growing role among the arsenal of equipment designed for transferring all kinds of information used in quite various fields of work. The further development of a communications system utilizing artificial earth satellites is called for in the "Main Guidelines for the Economic and Social Development of the USSR for 1981-1985 and for the Period to 1990" adopted at the 26th CPSU Congress.

The first artificial earth satellite in the world was launched by the Soviet Union on 4 October 1957 and from that time began the practical utilization of satellites for quite varied purposes. The first communications satellite--a "Molniya-1"--was launched in the Soviet Union on 23 April 1965. From the time of the launching of this satellite and through November 1981 107 communications and television broadcast satellites were placed in orbit in the USSR, including 86 satellites in highly elliptical orbit (52 "Molniya-1" satellites, 17 "Molniya-2" satellites and 17 "Molniya-3" satellites), 13 communications satellites (10 "Raduga" satellites and 4 "Gorizont" satellites) and 7 "Ekran" television broadcast satellites in stationary orbit.

The use of domestic communications satellites has made it possible to create in the Soviet Union working satellite systems for telephone and telegraph communications and for transmitting television programs, radio broadcasting programs and matrixes for central newspapers, as well as to organize communications and the exchange of television programs between participating countries of the international "Intersputnik" organization. Two types of communications satellites in highly elliptical orbit (the "Molniya-1" and "Molniya-3"), two types of communications satellites in stationary orbit (the "Raduga" and "Gorizont") and the "Ekran" television broadcast satellite are used at the present time in the USSR. These satellites are used in the territory of the USSR within the framework of the "Orbita", "Moskva" and "Ekran" satellite systems.

Communications satellites included in the structure of individual satellite communications systems (SSS's) make possible the transfer of both continuous (analog) and discrete information. Information to be transferred in analog form can be voice, phototelegraphy, television and other signals. Teletype signals, voice, television and phototelegraphy signals, as well as telecode (input and output) signals of automated control systems and computer networks, are transmitted in discrete (most often in digital) form. SSS radio links are as a rule multichannel.

Modern SSS's are distinguished by high communications reliability, minimum distortion in the transfer of large amounts of information, and the ability to enable communications with a considerable number of distant stations. The cost of transferring information through SSS links over distances of greater than 1500 km is lower than through ground communications channels. A very important feature of an SSS is the ability to implement global (worldwide) communications, along with the flexibility of the system. This is due to the fact that when using an SSS it is possible to link very quickly not only numerous (fixed) points on the surface of the earth, but also moving objects (ocean vessels, aircraft, spacecraft) and easily to change the direction, scope and types of communication.

Because of the use of the microwave band (e.g., the superhigh-frequency (SHF) band), it is possible to realize in an SSS high-quality transmission, a large frequency bandwidth and high carrying capacity and resistance to ionospheric disturbances. SSS's are widely used for transmitting telephone and telegraph messages, telecode information for various purposes, facsimile information, and sound and television broadcasting programs and for the exchange of television programs with various countries.

Of course, the Unified Automated Communications Network (YeASS) which is able to provide for the transmission of all kinds of information to users in the territory of the USSR, has now been created in our country. Telephone communications, the transmission of telegrams and phototelegrams, subscriber's telegraph communications, digital information for computers, the transmission of radio and television programs, as well as of telemetering and remote control signals between systems of automated complexes, are to be accomplished through the divided networks of the YeASS. All kinds of communications--ground (cable), radio relay and SSS--are harmoniously combined in the YeASS.

Communications satellites are widely used abroad, too. Dozens of national, regional and global SSS's can be counted in the world today. For example, the international Intelsat organization provides with satellite communications more than 100 countries via Intelsat satellites. In the territory of the Soviet Union communications and television broadcasting via Intelsat satellites are conducted by receiving-and-transmitting stations located in Dubna and in L'vov. The international Inmarsat organization, of which the USSR is a member, has been created for the purpose of providing marine communications between ocean vessels in the water areas of the Atlantic, Pacific and Indian oceans and coastal bases.

Local and regional SSS's have been created in a number of countries. Canada, the USA and Indonesia have national civil SSS's. The number of countries with their own civil SSS's will increase considerably in the next few years.

It should be mentioned that in recent years existing SSS's have undergone rapid development and the satellites themselves which are used have furthermore been modernized. The unit cost of a single communications channel in modern communications satellites is about 3 to 4 percent of that typical of first-generation communications satellites. The guaranteed service life of on-board satellite communications equipment has tripled as compared with first-generation satellites and has now reached 5 to 7 years. All this has made SSS's more efficient and economical.

Features of Satellite Communications System (SSS) Radio Links

Determination of the technical and operating characteristics of individual components of an SSS and of the parameters of receiving and transmitting equipment and the energy calculation of an earth-satellite-earth radio link do not differ in principle from those for ground radio communications links in the ultrashort-wave and microwave bands. In addition they have certain specifics which are usually taken into account in selecting the key specifications of links for an SSS to be employed.

The power of a UHF radio signal received on earth or by a satellite is directly proportional to the gain of the transmitting antenna. In addition, for accomplishing communications through an earth-satellite-earth radio link with specified quality and reliability, a certain signal-to-noise ratio in the receiver's input is required, which also depends on the gain of the transmitting antenna.

For the parabolic antennas which are used in the majority of cases in modern SSS's the gain is directly proportional to the diameter of the paraboloid. However, with an increase in the diameter of the antenna the width of the beam is reduced (at one and the same frequency). In addition, although the required gain and signal-to-noise ratio can be achieved when using antennas with large geometrical dimensions, the complexity and expense of these antennas are also limiting factors for employing antennas with ever greater diameters.

Ground antennas from 12 to 32 m in diameter are most often used for SSS's.

With very high gain of ground antennas the noise temperature of the earth, which reaches 300 K, begins to exert a substantial influence on their operation in the reception mode. This is especially felt when the antenna operates at low elevation.

Therefore, the minimum working elevation is assumed to be 5 to 7 degrees (and sometimes even 10 degrees). The gain-to-noise-temperature ratio for SSS ground antennas with a diameter of 25 m is usually 40.7 dB.

The possibilities and conditions for the use of specific elements of SSS radio links on earth and on a satellite are different. The lack of strict requirements with regard to weight, overall dimensions and consumption of electric power and the possibility of a human being's servicing the system make it possible to use at ground stations efficient large antennas, low-noise amplifiers, precise tracking systems and complicated input filters. Of course, the higher the power of the satellite transmitter the lighter and less expensive the ground facilities can become. However, the inevitable restrictions with regard to weight, size and power consumption of on-board systems make it appropriate to use relatively simple satellite transmitters of relatively low power.

That is why the initial criterion of departure which basically predetermines the operating and technical data for the basic elements of an SSS radio link is economizing on the power of the transmitter of the on-board relay station. In addition, in designing new SSS's it is necessary not to lose sight of the fact that a steady reduction in the cost of the output of the satellite's payload and reduction of the weight of on-board electric power supplies (with the same power) will without doubt be conducive in subsequent satellites to an increase in the power of on-board transmitters and to the simplification of ground receiving and transmitting equipment.

The necessity of increasing the power of on-board transmitters grows with an increase in the amount of information to be transmitted by means of the SSS (because of the restriction in the use of the frequency bands assigned for these purposes). However, with considerable power of on-board transmitters (greater than 100 W) the basic consumption of power is due to their output stages, whose efficiency is as yet low. When the power of on-board transmitters, in their current design, is increased, their reliability, as well as their service life, is somewhat reduced.

All these facts inevitably result in the need for added redundancy of on-board systems, which in turn results in an increase in the size and weight characteristics of satellites and in the additional input of electric power and, consequently, in an increase in the size of solar batteries and in the weight of on-board equipment. The maximum permissible noise level associated with the operation of ground radio communications links (radio relay, etc.) employing the same or close operating frequencies also imposes a limitation on the power of on-board transmitters. For all these reasons the power of on-board transmitters for satellites in stationary orbit is usually not greater than 150 to 200 W.

If increasing the power of on-board transmitters in principle would make it possible to simplify the receiving section of an SSS radio link on the ground, then the use on board the satellite of receiving-and-sending antennas with high gain would also be conducive to simplification of transceivers at ground stations. However, the use on board a satellite of antennas with high gain encounters not a few difficulties, in particular, on account of their large effective area.

As already mentioned, this is primarily restricted by the permissible size and weight of on-board equipment. It is true that with relatively low weight of on-board antennas it is possible to increase their efficiency and dimensions by using grid designs with deployment of the antenna after the satellite has been placed in orbit. However, this complicates the design both of the antenna itself and of the satellite as a whole. Quite effective also is the use on satellites of active phased arrays (AFAR's).

Finally, the effectiveness of on-board antennas could be increased on account of high directivity of their effect. But this complicates on-board earth tracking systems and imposes stricter requirements on on-board attitude control and stabilizing systems. Furthermore, it would be very difficult to lower the level of noise in antennas and satellite receivers to the required quite insignificant value.

Difficulties along the way of improving the effectiveness of on-board antennas for communications satellites have made it necessary to create large ground antennas and to amplify their radiating power, which also makes it possible to use relatively small and simple on-board antennas with low effective directivity. However, the capabilities of ground transmitters are far from limitless; they are limited by many factors. For example, the increasing "tightness" in the distribution of satellites in stationary orbit will possibly create various "conflict situations" in frequency bands and make it necessary to take into account the polarization of radiation in satellites close to one another in stationary orbit.

The choice of operating frequencies, the sensitivity of receivers and the power of transmitters, determination of the type of ground and on-board antennas--all these are questions of a complex nature which must be linked up with one another in designing an SSS and must be reconciled with the specific conditions of its operation.

Since ground equipment is not infrequently shared, not only by several communications satellites but even by various SSS's, the parameters of on-board receivers, transmitters and antennas must be determined by taking into account the technical capabilities of ground control equipment and, in particular, of antennas and other SSS ground systems already in use.

The choice of frequencies for SSS radio links is determined by the conditions for the propagation of radio waves, by their absorption and scattering, as well as by the level of external noise, by the technical characteristics of the equipment of receiving and transmitting systems, and by the lack of occupancy of a given band by other systems and kinds of communication. In choosing frequencies for an SSS, in addition to general criteria (level and form of signal, amount of noise and losses in propagation in the medium), it is necessary to take into account also the specific nature of the influence of the troposphere and ionosphere, the effect of cosmic noise and the specifics of communication with moving objects.

The need to enable communication with objects found in high layers of the atmosphere and ionosphere makes it necessary that radio waves with the frequencies used in SSS radio links possess the ability to pass through the ionosphere without important losses. This condition has been responsible for the use in SSS's of the ultrashort-wave band and higher frequencies. Of course, radio waves with the frequencies used in SSS's must pass without difficulty through the entire thickness of the atmosphere. Here it is necessary to take into account the absorption of radio waves in the lower layers of the atmosphere (troposphere) extending for a few dozen kilometers, where the absorption of the energy of radio waves can be considered proportional to the length of the path of the propagation of radio waves there. Humidity, fog, rain and snow also increase the influence of the atmosphere on the passage of radio waves in it.

In addition to the stationary, i.e., steady, nature of the effect of the atmosphere on the propagation of radio waves, an influence is exerted on them by perturbations of a fluctuation nature caused by rapid changes in the concentration of electrons in the ionosphere, in temperature, humidity and pressure in the earth's atmosphere.

Cosmic radio noise, caused by interference created by the galaxy, sun and moon and reducing the level of radio signals, also depends on the state of the atmosphere and is reduced with an increase in the operating frequencies of SSS radio links. When a communications satellite is in an auroral pole area the additional absorption of radio wave energy is possible because of a sudden increase in the local electron concentration of the ionosphere, which is capable of resulting in a total loss of communication (especially at frequencies below 100 MHz).

In setting up radio communications with moving objects or by means of moving objects it is necessary, of course, to take into account the Doppler effect, which also influences radio signals. As a result of the Doppler effect the received radio signal (at the satellite or on the earth) appears to be stretched out over time and the frequency of the received signal differs from the frequency of the transmitted signal.

However, experience in operating SSS's has demonstrated that in telephone and telegraph communications and in transmission of a black-and-white television picture the Doppler effect has almost no influence and in transmission of a color television picture its influence is slight and in the majority of cases can be disregarded. The influence of the Doppler effect must be taken into account in the transmission of radio signals of a measuring nature, as well as of some other types of information.

At the present time in SSS's, in particular of a global nature, the need not infrequently arises of transmitting messages via two satellites or of accomplishing direct communication between satellites (fig 7). In these cases the troposphere does not influence the propagation of radio waves and therefore limitations on the upper limit of the frequency band caused by absorption by the troposphere are eliminated. It must be mentioned that when operating at frequencies from 100 MHz to dozens of GHz the absorption of radio waves by the earth's atmosphere is usually not taken into account in an SSS.

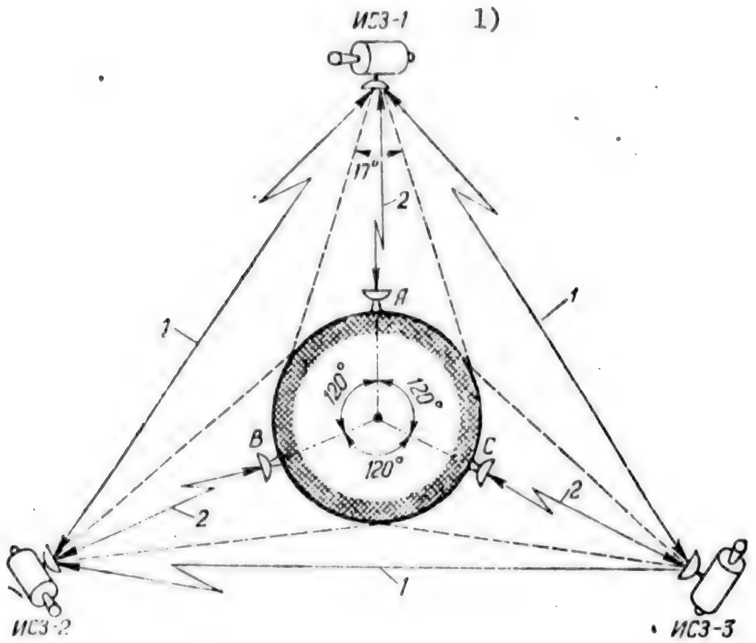

Figure 7. Diagram of Global Communications Using Three Stationary Satellites with Relaying Between Satellites: A, B, C--ground stations; 1--satellite-satellite radio links; 2--earth-satellite and satellite-earth radio links

Key:
1. Satellite No 1

An analysis of the joint influence of the troposphere, ionosphere and outer space, as well as taking into account the technical and operating capabilities of on-board and ground receiving-and-transmitting equipment, lead to the conclusion that the acceptable optimum region of operating frequencies for SSS's is, in particular, the range from 1 to 15 GHz. Furthermore, with an increase in the directivity of SSS on-board and ground antennas it becomes ever more advisable to use still higher frequencies. Their optimum choice for SSS's encounters no small difficulties, since the wide frequency bands convenient for SSS's are also used in other types of communication.

At the International Administrative Conference on Radio Communications which convened in 1976 a decision was made according to which the 11.7 to 12.5 GHz band was assigned for providing for multiprogram satellite television broadcasting. At subsequent conferences this band was supplemented with a few more, in particular, for satellite broadcasting directly to home receivers. Specific sections in these bands were set aside for existing SSS's and those in the planning stage, the positions of satellites in stationary orbit were coordinated, and the time for the transmission of television programs and the specifications for directivity of the effect of communications and television-broadcasting satellite antennas were agreed upon.

Planning of the operation of SSS's within the framework of international agreements has made it possible to eliminate possible overlapping and interference during the simultaneous operation of communications satellites, in particular of stationary satellites. As already stated, it has now already become rather "tight" in stationary orbits, where in the 1980's and 1990's plans have been made for the placement by various countries and organizations of a quite considerable number of satellites both for communications purposes and for other purposes. According to an international agreement, in order to avoid mutual interference stationary satellites operating at identical or close frequencies must be placed at an angular distance of not less than 2 to 5 degrees from one another (and the angular dimension of all stationary orbits is a total of 360 degrees). Of course, this restriction does not threaten SSS's utilizing satellites in highly elliptical orbits.

Soviet Satellite Communications Systems Employing "Molniya" Satellites

The first "Molniya-1" communications satellite in the Soviet Union was put in orbit on 23 April 1965. This launch marked the beginning of the existence of Soviet long-range satellite communications systems (SSS's). For many months the first "Molniya-1" satellite provided telephone communication between Moscow and the Far East. With the launching of the second "Molniya-1" satellite on 14 Oct 1965 the experimental operation of long-range two-way television and telephone and telegraph communications by means of an SSS was begun. The third "Molniya-1" satellite put in orbit on 25 April 1966, in addition to communications within the Union and television broadcasting, was also used for the exchange of television programs between the USSR and France, including color television.

As already mentioned, satellites of the "Molniya-1" type have been put in highly elliptical orbit with an altitude at apogee of about 40,000 km above the earth's northern hemisphere (table 1).

The "Molniya-1" satellite is furnished with equipment of two types: auxiliary (service) and special. Its on-board service equipment includes general-purpose systems, instruments and units ensuring the good working order of the satellite, as well as for testing its condition and for in-flight control regardless of the nature of tasks to be performed.

The service equipment of the "Molniya-1" satellite includes satellite power supplies and equipment, such as nickel cadmium batteries, semiconductor solar batteries (SB's) and current distribution equipment. In particular, six panels of solar batteries which are uncovered after the satellite is put in orbit are installed on the satellite. The presence of solar and buffer storage batteries makes it possible to use the "Molniya-1" satellite when it is on both the sunlit and shaded sides of the earth.

Table 1. Summary Table of "Molniya-1" Satellite Launchings

No	Date of launching	Altitude at perigee, km	Altitude at apogee, km	Inclination, deg	Orbital period h	min
1	23.04.1965	548	39 957	65	12	00
2	14.10.1965	500	40 000	65	11	59
3	25.04.1966	499	39 500	64,5	11	50
4	20.10.1966	485	39 700	64,9	11	53
5	25.05.1967	460	39 810	61,8	11	55
6	31.08.1967	500	39 750	61,5	11	55
7	03.10.1967	465	39 600	65	11	52
8	22.10.1967	456	39 740	64,7	11	54
9	21.04.1968	460	39 700	65	11	53
10	05.07.1968	470	39 770	65	11	55
11	05.10.1968	490	39 600	65	11	52
12	16.12.1968	500	39 600	65	11	52
13	11.04.1969	470	39 700	65	11	53
14	22.07.1969	520	39 540	64,9	11	51
15	19.02.1970	487	39 175	65,3	11	43
16	26.06.1970	470	39 280	65	11	45
17	29.09.1970	480	39 300	65,5	11	46
18	27.11.1970	435	39 430	65,3	11	47
19	25.12.1970	480	39 600	65	11	52
20	28.07.1971	470	39 300	65,4	11	45
21	20.12.1971	490	39 200	65,5	11	47
22	04.04.1972	480	39 260	65,6	11	45
23	14.10.1972	480	39 300	65,3	11	45
24	02.12.1972	500	39 100	65	11	43
25	03.02.1973	470	39 200	65	11	43
26	30.08.1973	480	37 970	65,3	11	19
27	14.11.1973	480	39 140	65	11	42
28	30.11.1973	460	40 900	62,7	12	17
29	20.04.1974	646	40 713	62,9	12	18
30	29.07.1974	35 580	35 580	0,4	23	59
31	24.10.1974	683	40 617	62,8	12	16
32	29.04.1975	468	40 848	63	12	17
33	05.06.1975	450	40 890	63	12	17
34	02.09.1975	689	40 681	62,8	12	17
35	22.01.1976	491	38 934	62,5	11	38
36	11.03.1976	518	40 683	62,5	12	14
37	19.03.1976	494	38 984	63	11	39
38	23.07.1976	499	39 059	62,9	11	41
39	21.03.1977	484	40 816	62,8	12	16
40	21.06.1977	480	39 016	62,9	11	40
41	30.08.1977	480	40 800	62,8	12	16
42	03.03.1978	632	40 733	62,8	12	18
43	02.06.1978	457	40 837	62,5	12	16
44	14.07.1978	650	40 660	62,8	12	17
45	12.04.1979	656	40 590	62,9	12	15
46	20.10.1979	640	40 640	62,8	12	16
47	11.01.1980	478	40 830	62,8	12	17
48	21.06.1980	658	40 707	62,8	12	18
49	16.11.1980	640	40 651	62,8	12	16
50	30.01.1981	464	40 801	62,8	12	16
51	24.06.1981	465	40 640	62,8	12	16
52	17.11.1981	472	39 117	62,8	11	42

In addition, the service equipment of the "Molniya-1" satellite includes temperature control system equipment in the form of a combination of instruments which monitor the temperature conditions of individual units and systems and the satellite as a whole and maintain a specific temperature on board by actuating controls which regulate thermal processes--a cooling radiator, heating panel, etc. The service equipment also includes systems for maintaining the pressure within the satellite and for testing it.

Other units of service equipment include the instruments of the attitude control and stabilizing systems, which make possible the required position in space of both the satellite itself and its individual elements having independent attitude control (e.g., antennas and solar battery panels), as well as a correcting propulsion system designed for correcting the orbit, thrusters (controls) and the so-called working medium (compressed gas) for correcting the satellite's orbit. These corrections are made periodically for the purpose of eliminating inaccuracy in placement in orbit and for compensating the effect of various perturbing forces.

The on-board automation equipment, also included in the service equipment, is in the form of electronic timed instruction equipment serving the purpose of issuing a series of various instructions to individual instruments and systems of the satellite in keeping with the operating logic of on-board systems and flight objectives and according to programs which are relayed from the earth. The service equipment of the "Molniya-1" satellite also includes control equipment designed for regular measurement of the path, for in-flight checking of the condition of satellite systems and for transmitting information regarding this to the earth for telemetering purposes, as well as equipment for reception, transmission and checking the execution of instructions--so-called command radio link equipment.

Finally, the service equipment includes an on-board cable system by means of which switching and current distribution on board the satellite are accomplished.

The communications equipment comes directly under the heading of the special on-board equipment of the "Molniya-1" satellite. It includes antennas for the reception and transmission of earth-satellite-earth radio signals and the systems, involved in their operation, for tracking and driving antenna units. The two antennas of the "Molniya-1" satellite are parabolic; they have a folding grid design and open after the satellite has been placed in orbit. The antennas are oriented toward the center of the earth during the entire flight.

The special equipment of the "Molniya-1" satellite includes a repeater consisting of receiving, converting and amplifying units. The basic elements of this repeater are the receiver, converting unit and a traveling wave tube power amplifier. The use of this tube makes it possible to achieve high gain over a wide frequency band with a low level of noise and distortion and relatively high efficiency. It should be mentioned that four repeaters are installed in a "Molniya-1" satellite--a main and three standby which, if necessary, are able to substitute for the main one.

An [illegible] radio link employing a "Molniya-1" satellite operates in the 800 to 1000 MHz frequency band. The radiated power of the transmitter is about 40 W.

Let us now consider how an SSS utilizing a "Molniya-1" satellite operates when carrying out telephone communications, for example (fig 8).

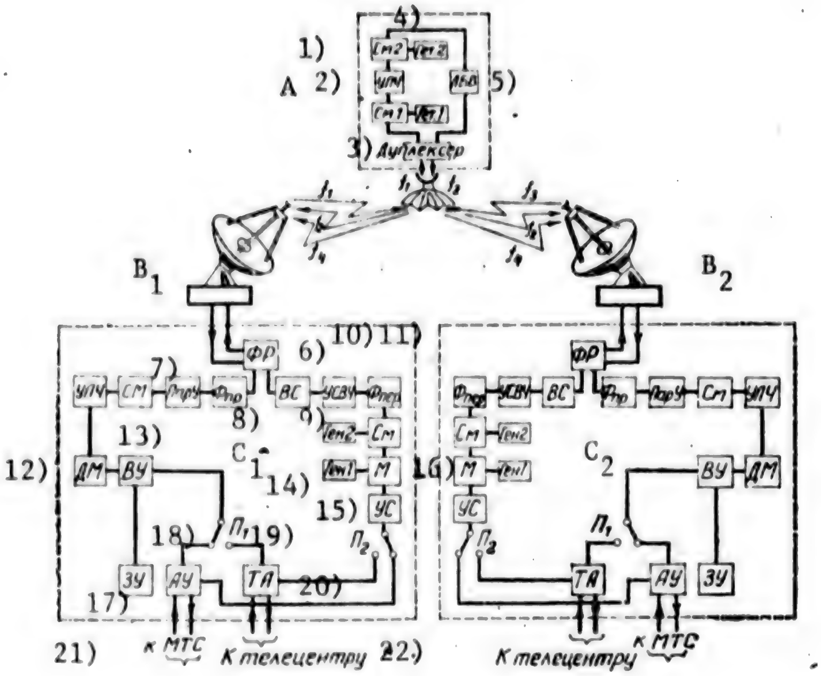

Figure 8. Block Diagram of Satellite Communications System Using a Satellite of the "Molniya" Type: A--simplified block diagram of on-board repeater; B_1 and B_2--ground antennas; C_1 and C_2--simplified block diagrams of ground stations of the "Molniya" communications complex

Key:

1. Mixer No 2
2. Intermediate frequency amplifier
3. Duplexer
4. Local oscillator No 2
5. Traveling wave tube
6. Isolation filter
7. Parametric amplifier
8. Reception filter
9. Output stage
10. Microwave amplifier
11. Transmitting filter
12. Demodulator
13. Video amplifier
14. Oscillator No 1
15. Amplifier
16. Modulator
17. Recorder
18. Multiplexer
19. Selector switch
20. Television set
21. To long-distance telephone exchange
22. To television center

Signals from the telephone set are transmitted through the local telephone exchange to the long-distance telephone exchange (MTS), from which they enter through connecting lines the ground receiving-and-transmitting station of the SSS. Passing through the multiplexer (AU), the signals are transmitted through the amplifier (US) to the modulator (M), in which the oscillations created by the oscillator

(Gen. 1) are modulated. Then the modulated oscillations enter a mixer (SM) to which oscillations are also supplied, but from another oscillator (Gen. 2).

The modulated oscillations are picked up from the output of the mixer through a filter (F_{per}) and are fed to a microwave amplifier (USVCh). Then they are directed through a waveguide or feeder to the antenna from the output stage (VS) through an isolation filter (FR). The ground antenna, tracking the motion of the satellite by means of special guidance systems and a drive, sends these signals, say in the 1000 MHz band, to the satellite, where via a parabolic antenna and isolation filter they enter the receiver's mixer (SM1), are converted with respect to frequency, are amplified (UPCh) and after secondary frequency conversion (SM2) they are transferred to the power amplifier stage of a transmitter constructed with traveling wave tubes (LBV's).

After power amplification, the signal, passing through the isolator (duplexer), is radiated to the earth in the form of a narrow beam having a frequency, say, in the 800 MHz band. Thus, the signal from the transmitting station, having undergone frequency conversion on board the "Molniya-1" satellite, having provided for the difference in signals before and after its relaying, and also having received the appropriate amplification, is sent to the antennas of the receiving ground station.

The signals received by the ground station's antenna enter the station's receiver via an isolation filter. Passing through the receiver's filter, parametric amplifiers (ParU's), a mixer (SM), an intermediate-frequency amplifier (UPCh) and a demodulator (DM), the signal is sent via a set of multiplexing equipment (AU) to the long-distance and then to the local telephone exchange to the subscriber. The video amplifier (VU) and recorder (ZU) indicated in fig 8 are used in television transmission.

Cassegrain antennas are usually used at ground stations of SSS's utilizing "Molniya-1" satellites, which makes it possible to increase their efficiency as compared with single-reflector antennas with the same surface of the main reflector. The operation of the drives and tracking of these antennas requires high accuracy, as well as a minimum level of intrinsic noise.

The equipment of ground stations makes it possible to track the signal both from a program unit according to a precalculated program based on values of the parameters of the satellite's orbit, and in the automatic tracking mode from a radio signal received from on board the satellite. In the latter instance the antenna is continuously controlled in terms of angular coordinates by means of a tracking system which reacts to the error signal generated by the tracking equipment.

The considerable output power of ground stations (for "Molniya-1" satellite radio links it equals about 5 kW), high stability of the carrier frequency, great width of the frequency band for all stages of the circuit passing and amplifying modulated oscillations--all these are the necessary characteristics of the transmitters of SSS ground stations.

High sensitivity and a low level of intrinsic noise are features of the receivers of these stations. The use of low-noise cooled amplifiers provides an advantageous signal-to-noise ratio and at the same time the required reception quality. It should be mentioned that the system operates satisfactorily also without cooling of the parametric amplifiers. For the purpose of improving the operating and technical characteristics of receivers and for reducing losses of power and noise, the high-frequency section is placed in the cabin in the direct vicinity of the antenna outlet. The remaining portion of the receiving system equipment is in the equipment room.

At each ground station there are two operating receiver units. Reception from another station takes place at the first (it is called the working receiver) and by means of the second (the control receiver), the reception of its own signal after it is emitted from the satellite.

SSS ground stations are equipped with various kinds of equipment for checking the correctness and reliability of the system's operation and the quality of all kinds of communication. Input switching equipment and instruments for checking intermediate and low frequencies and for testing the operation of receivers are installed in the receiving equipment room. Observations of the level of signals in certain points of the circuit are carried out and various quality indicators of satellite channels are monitored continuously by means of monitoring and testing equipment.

The transmission of television signals through the channel for the transmission and conversion of signals differs little from that which we discussed in the case of telephone communications (switching of the system from telephone messages, say, to the transmission of television pictures is conventionally indicated by switches P_1 and P_2 in fig 8). In the equipment room for monitoring the television signal, in addition to equipment for separating and combining video and audio signals there are instruments for monitoring scan lines and a video monitor making it possible to follow the quality of reception or transmission.

The most important element of monitoring and switching equipment at an SSS ground station is the central control station, to which are supplied the signals of monitoring pickups installed in receiving, transmitting and television equipment. The circuits of automation equipment are also led here, by means of which changes are made in the operating modes of systems and individual elements of a system are made redundant.

Two main directions can be distinguished fairly clearly in the operation of an SSS: control of the flight of a satellite, and the organization of communications via a satellite in keeping with the operating plans and schedules of the SSS. Monitoring of the position of the satellite in space, measurements of travel time, determination of elements of the orbit and its correction, forecasting the satellite's travel, checking (from telemetering data) the condition and correctness of the functioning of on-board systems and diagnosing them, monitoring the consumption of the satellite's energy resources and observance of the established energy balance, issuing to the satellite current programs and single instructions, checking their transmission, as well as several other control functions--all this is performed by the services and facilities of the ground automated measuring and command control complex.

Optimum channel formation, efficient use of the SSS for various kinds of communication (telephony, telegraphy, data transmission, television, etc.) in keeping with established operating schedules and newly arising assignments, coordinating the modes of earth-satellite-earth equipment and the operating cycle with ground long-distance exchanges, with a telegraph, television center and cable line facilities, and organizing steady interaction with them, controlling the quality of communications and eliminating every kind of noise, and servicing communications equipment--all this is directly the basic obligation of the ground communications complex.

At the same time the timely revelation of deviations in the operation of instruments, the cutting off of instruments which are malfunctioning and have used up their safe life, the switching to standby systems, preserving in every possible way the good working order of satellite systems and communications equipment, ensuring the maximum life of a satellite, and instantaneous correction of the operating programs of a system are the most important tasks of both control and communications personnel working, of course, in complete steady contact with one another.

Finally, let us note that ground SSS stations employing "Molniya" type satellites are divided into central, peripheral and transportable. The greatest exchange of information is accomplished through central stations and in addition they perform the managing and coordinating role in the operation of an SSS. In addition to active stations, there are always one or two standby central stations which under conditions of normal regular operation perform the role of peripheral stations.

Subsequent modernization of satellites of the "Molniya-1" type resulted in the creation of satellites of the "Molniya-2" type and then of satellites of the "Molniya-3" type. In these, in particular, was used the higher (SHF) frequency band of 4 to 6 GHz, which has made it possible to increase severalfold the number of telephone and telegraph communications channels. The change to higher frequencies also made it possible to improve the quality of television pictures. The entry into service of "Molniya-2" and "Molniya-3" satellites developed in accordance with the latest international standards and recommendations (for frequencies, noise immunity and other indicators) expanded the multimillion satellite television audience and expanded the possibilities of exchanging television and other information between the USSR and every country in the world.

The first "Molniya-2" satellite was put in orbit on 24 November 1971 and the second on 19 May 1972. With the launching of these satellites the international "Intersputnik" SSS went into operation, the agreement for the creation of which was signed in 1971 between the USSR and other countries. At the first stage of activity of the "Intersputnik" organization communications were accomplished by means of highly elliptical satellites of the "Molniya" type, and then by means of "Gorizont" stationary satellites.

Ground stations for SSS's employing "Molniya" type satellites, constructed in participating countries of the "Intersputnik" organization, were furnished with parabolic antennas 12 m in diameter. The output power of these ground stations reached 3 kW. The creation of "Molniya-2" satellites became an important stage in the development of SSS's in the Soviet Union and was responible for its further achievements in this area (cf. table 2).

Table 2. Summary Table of Launchings of "Molniya-2" Satellites

No	Date of launching	Altitude at perigee, km	Altitude at apogee, km	Inclination, deg	Orbital period	
					h	min
1	24.11.1971	460	39 350	65,4	11	46
2	19.05.1972	460	39 300	65,5	11	45
3	30.09.1972	480	39 200	65,3	11	43
4	12.12.1972	470	39 300	65,3	11	45
5	05.04.1973	500	39 100	65	11	42
6	11.07.1973	480	39 280	65,3	11	45
7	19.10.1973	630	40 600	62,8	12	16
8	25.12.1973	466	40 865	62,8	12	17
9	26.04.1974	463	40 850	62,9	12	17
10	23.07.1974	460	40 900	62,8	12	17
11	21.12.1974	641	40 675	62,9	12	17
12	06.02.1975	640	40 685	62,8	12	17
13	08.07.1975	465	40 864	62,8	12	17
14	09.09.1975	470	40 836	62,8	12	16
15	17.12.1975	451	40 836	62,8	12	16
16	02.12.1976	657	40 608	62,8	12	16
17	11.02.1977	493	40 757	62,5	12	15

The first "Molniya-3" satellite was launched in the Soviet Union on 21 November 1974. The orbits of satellites of this type are similar in their parameters to those of "Molniya-1" and "Molniya-2" satellites (cf. table 3).

Table 3. Summary Table of Lauchings of "Molniya-3" Satellites

No	Date of launching	Altitude at perigee, km	Altitude at apogee, km	Inclination, deg	Orbital period	
					h	min
1	21.11.1974	650	40 690	62,8	12	17
2	14.04.1975	636	40 660	63	12	16
3	14.11.1975	470	40 830	62,4	12	16
4	27.12.1975	470	40 800	62,8	12	16
5	12.05.1976	652	40 660	62,8	12	16
6	28.12.1976	640	40 630	62,8	12	16
7	28.04.1977	467	40 812	62,8	12	16
8	28.10.1977	478	40 764	62,8	12	15
9	24.01.1978	661	40 631	62,8	12	16
10	13.10.1978	467	40 825	62,8	12	16
11	18.01.1979	474	40 806	62,8	12	16
12	06.06.1979	473	40 769	62,5	12	15
13	18.07.1980	467	40 815	62,8	12	16
14	09.01.1981	485	40 784	62,5	12	16
15	24.03.1981	641	40 655	62,8	12	16
16	09.06.1981	471	40 837	62,8	12	16
17	17.10.1981	649	40 644	63	12	16

Just as for "Molniya-2" satellites, the 5 to 6 GHz band is used here. In addition to this the repeater of a satellite of the "Molniya-3" type has three channels and it is possible to transmit through each of them one television program or to establish a great number of telephone or telegraph communications. Usually in modern SSS's it is possible to pass about 800 simplex telephone channels through each broadband telephone channel.

Satellites of the "Molniya-3" type along with satellites of the "Molniya-1" type have become widely used in the Soviet "Orbita" SSS, which is discussed in greater detail shortly below.

Features of the Utilization of Stationary Satellites

As already stated, the use of satellites in geostationary or stationary orbit has a number of advantages, in particular, with respect to the wide area of view (of control) of near-earth space and of the earth's surface (up to 42 percent of the area of this surface), the ability for the continuous (without on-board storage) transfer of information to a great number of ground stations located over an extensive area of the globe, and of making possible global communications by means of a smaller number of satellites. In addition, for the purpose of making possible communications with stationary satellites it is possible to be limited to the use of a single set of antenna equipment without program control of the ground station's antenna and through simplified target indications from the earth.

Special importance is attached to satellite communications systems utilizing stationary satellites also because they are able to gather extensive information from an enormous number of stationary and mobile (ocean vessels, aircraft, satellites, etc.) points with its undelayed transfer to information gathering and processing centers and to command stations, as well as to transmit various group messages from a center immediately to all points.

In addition, for placing satellites in stationary orbit more powerful satellite rockets are required and therefore it is no wonder that prior to 1981 the launching of these satellites (if experimental ones are not taken into account) was accomplished by means of only Soviet and American rockets.

Satellites can be placed in stationary orbit by various methods, but two of them are the most advantageous from the viewpoint of input of energy and time: the 2-impulse and 3-impulse. In either of these two cases the satellite is first placed in so-called reference orbit, which is almost circular at an altitude of about 200 km and inclination of 51 degrees. In the 2-impulse method the satellite, in reference orbit, in the first loop, is given a boost which transfers the satellite into highly elliptical orbit whose apogee and perigee are in the plane of the equator. The satellite receives its second boost when it is at the apogee of the highly elliptical orbit, as the result of which the satellite's orbital inclination is reduced to zero and the altitude at perigee reaches the altitude of stationary orbit.

In the 3-impulse method the first impulse (acceleration) is imparted to the satellite at the point of intersection of the reference orbit with the plane of the equator. As a result, the first transfer highly elliptical orbit is formed, whose apogee and perigee lie in the plane of the equator, whereby the apogee altitude is higher than the altitude of stationary orbit and the perigee altitude is equal to the reference orbit altitude (the inclination is the same as in reference orbit). After the second impulse (turn of the plane of orbit and re-acceleration), imparted to the satellite at the point of the apogee of the first transfer orbit, it is transferred to the second highly elliptical transfer orbit with an altitude at perigee equal to the stationary orbit altitude and lying in the plane of the equator. Formation of the satellite's stationary orbit is finally concluded by means of a third impulse (deceleration) received by the satellite at the moment it passes the perigee of the second transfer orbit.

When satellites are launched into stationary orbit from the territory of the USSR, the 3-impulse method of injection into orbit is more advantageous from the energy standpoint, whereas the 2-impulse method is more advantageous when launching from space launch complexes in the USA (closer to the equator). Furthermore, the advantage of the 3-impulse method of putting a satellite into stationary orbit is greater the higher the apogee altitude of transfer orbits. A certain disadvantage of the 2-impulse method is the fact that with a specific launching time it makes it possible to place a satellite in stationary orbit only with a certain longitude interval (11.25 degrees) of the satellite's "anchor stations." This is associated with the fact that the plane of orbit is turned from the reference and not from the highly elliptical orbit. With the 3-impulse method the longitude of the satellite's "anchor station" in stationary orbit is not restricted by the launching time and is made possible by the appropriate apogee altitude of the transfer orbit.

The need for a correcting propulsion system on board stationary satellites is caused both by the problems of placing in stationary orbit and by the fact that, once in it, the satellite steadily undergoes a number of perturbations. These include perturbations resulting from the inhomogeneity of the earth's gravitational field, the perturbing effect of the gravitational fields of the moon and sun, and even light pressure. For example, light pressure causes long-period movement of satellites up to 100 km along their orbit and up to a few dozen kilometers with respect to altitude for relatively light but large satellites (the greater the weight of a satellite and the smaller its dimensions the slighter the influence of light pressure on its orbit).

The oblateness of the earth at its poles causes drifting of a satellite by almost 9.8 degrees per year along its stationary orbit and results in periodic perturbations with respect to altitude and inclination with a range of up to 3 km and in a change in other orbit parameters. As a result of deviations of the earth's equator from an ideal circle, a stationary satellite is shifted by approximately 3.3 degrees along its orbit in only 2 months and its position in terms of altitude fluctuates by more than 8 km. The maximum perturbation resulting from equatorial compression is reached near "anchor stations" at 30 and 120 degrees east longitude and 60 and 150 degrees west longitude. On the other hand, the most stable "anchor stations" for stationary satellites are 75 degrees east longitude and 105 degrees west longitude.

A number of secular perturbations of the position of a satellite in stationary orbit can be eliminated by correction carried out after the satellite has been placed in orbit. For example, secular perturbations of position in the plane of orbit caused by the influence of polar flattening can be compensated by increasing the altitude of the orbit and by an appropriate increase in the satellite's travelling speed. However, with this the effect of other perturbing factors remains uneliminated (especially resulting from the earth's equatorial flattening), which results in particular almost always in a change in the longitude of a stationary satellite's "anchor station." Consequently, sporadic correction of the motion of stationary satellites is necessary, correcting their orbit.

The number of corrections depends on the permissible amount of a stationary satellite's drift in terms of longitude per year. Generally, if the satellite's permissible drift must not exceed 1 to 4 degrees, then it is necessary to make up to six corrections per year. No more than one correction per year is required at points of the stable position of stationary satellites.

For the purpose of monitoring the operation of on-board systems and for controlling the flight of a satellite in keeping with objectives, it is necessary to know with certain precision the parameters of the motion of a satellite in stationary orbit. The duration of scheduled "regular" measuring sessions for stationary satellites observed from the territory of the USSR is 10 to 15 min for each 6 h of the satellite's flight. Regular sessions for radio control of the orbit of a satellite are conducted approximately every two months before and after making so-called "slight" corrections. In addition, after separation of a satellite and after "big" corrections carried out for the purpose of eliminating placement errors, regular sessions for radio control of orbit are conducted every 1.5 to 2 h.

Since the presence in stationary orbit of even unoperating satellites hampers utilization, various methods exist by means of which it is possible to withdraw unneeded bodies (including stages of satellite rockets, too) from stationary orbit. These methods include transferring a satellite to highly elliptical, parabolic or quasi-stationary orbits, as well as returning an object to earth or transferring it to the point of a stable position. When satellites are transferred to highly elliptical orbit with the altitude at perigee in sufficiently dense layers of the atmosphere the deceleration and burnup of the satellite is achieved in these layers.

By transferring a satellite to parabolic orbit it is possible to remove it from the earth's range of influence. This method is equivalent from the energy standpoint to the method of transferring a stationary satellite to highly elliptical orbit. The return of a satellite to earth can be made possible also by means of a multiple-use space system, which requires a great input of energy.

The transfer of a stationary satellite to a quasi-elliptical orbit or one close to it is advantageous in the energy respect. However, with the state of the art of space rocket technology the method of transferring stationary satellites to other longitudes of their "anchor station" and to points of a stable position in orbit is perhaps the most advantageous.

Satellites to be launched into stationary orbit must be registered according to the established procedure at the International Telecommunications Union (ITU), of which the USSR is a member. According to the so-called "Radio Communications Regulations," the ITU is the only agency having the right to solve problems relating to the distribution of radio frequencies among the satellite communications systems (SSS's) of various nations. A country creating an SSS must beforehand, but not earlier than five years before launching the satellite, send a declaration to the International Frequency Registration Board (IFRB) containing the key frequency data for the SSS radio link, data on the satellite's orbit, the areas which the SSS will serve, maximum operating times, the class of ground stations to be used, etc. All of this is published in a weekly circular and if over a period of three months from the time of publication comments are not received from individual agencies, the SSS is considered registered.

According to existing international agreements, the registration by ITU of frequency assignments for SSS services and their use must not give any priority to any individual country or group of countries and must not prevent the creation of an SSS by other countries. In addition, countries or groups of countries for which ITU has registered frequencies for SSS services must take every possible measure to realize the possibility of the new SSS's being used by other countries or groups of countries desiring this.

The first Soviet satellite (the "Kosmos-637") was put in stationary orbit on 26 March 1974, and on 22 December 1975 the first "Raduga" stationary communications satellite was launched in the Soviet Union. The first "Ekran" television broadcasting satellite was placed in stationary orbit on 26 October 1976 and on 19 December 1978 the first communications satellite of the "Gorizont" type. All these types of Soviet stationary satellites are used at the present time in the "Orbita", "Moskva" and "Ekran" SSS's (table 4).

SSS's now existing or being planned for other countries and international organizations, unlike the Soviet Union, are based on the use of just stationary satellites. Plans have been made to launch about 200 foreign stationary satellites in the 1980's and 1990's.

"Orbita"--the First Soviet Satellite Communications System

At the present time because of the extensive utilization of the modern achievements of science and technology, including space technology, television and radio broadcasting, having developed at an accelerated pace, exert an enormous influence on many aspects of the life of modern man. In the majority of countries of the world the broadcasting audience has increased, the number of television programs broadcast has grown and the quality of broadcasts has improved.

In our country radio broadcasts can be received by the entire population and a very high percentage of the population is able to view television broadcasts. For the purpose of including the entire population of the country in the television viewing audience, in addition to the traditional methods of transmitting television programs through cable and radio relay lines, methods based on the use of satellites launched into both highly elliptical and stationary orbit are being developed extensively.

In 1967, soon after the launching of the first satellites of the "Molniya-1" type, the "Orbita" television distribution network was created on their basis in the Soviet Union. In addition to Central Television broadcasts, not a few stations of the "Orbita" distribution network are used also for receiving radio broadcast programs, for phototelegraphy traffic, for telephone and telegraph communications, and for transmitting matrixes for central newspapers.

Table 4. Summary Table of Launchings of "Raduga", "Gorizont" and "Ekran" Satellites

№	1) Дата запуска	2) МРН*	3) Элементы орбиты				
			4) Точка стояния	5) Высота, км	6) Наклонение, град.	7) Период обращения	
						8) ч	мин 9)
	10)	11)	«Радуга»				
1	22.12.1975	С-1	85° в. д.	35 800	0,3	23	54
2	11.09.1976	С-1	85° в. д.	35 900	0,3	24	00
3	24.07.1977	С-2	35° в. д.	36 600	0,4	24	37
4	19.07.1978	С-2	35° в. д.	36 590	0,5	24	38
5	25.04.1979	С-1	85° в. д.	36 000	0,4	24	02
6	20.02.1980	С-2	35° в. д.	36 610	0,4	24	38
7	05.10.1980	С-3	85° в. д.	36 600	0,4	24	04
8	18.03.1981	С-2	35° в. д.	36 590	0,4	24	37
9	31.07.1981	С-2	35° в. д.	36 690	0,4	24	37
10	09.10.1981	С-3	85° в. д.	35 900	0,4	24	02
		12)	«Горизонт»				
1	19.12.1978	С-5	53° в. д.	48 365	11,3	23	40
2	06.07.1979	С-4	14° з. д.	36 550	0,8	24	37
3	28.12.1979	С-5	53° в. д.	36 300	0,8	24	23
4	14.06.1980	С-4	14° з. д.	36 515	0,8	24	33
		13)	«Экран»				
1	26.10.1976	С-Т	99° в. д.	35 600	0,3	23	42
2	20.09.1977	С-Т	99° в. д.	35 560	0,4	23	45
3	21.02.1979	С-Т	99° в. д.	37 780	0,35	23	56
4	03.10.1979	С-Т	99° в. д.	35 557	0,45	23	44
5	15.07.1980	С-Т	99° в. д.	35 474	0,36	23	40
6	24.12.1980	С-Т	99° в. д.	35 554	0,4	23	44
7	26.06.1981	С-Т	99° в. д.	35 636	0,4	23	46

Key:

1. Date of launching
2. MRI*
3. Orbit elements
4. Anchor station
5. Altitude, km
6. Inclination, degrees
7. Orbital period
8. h
9. min
10. 22 December 1975
11. "Raduga"
12. "Gorizont"
13. "Ekran"

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*The abbreviation S-1, -2, -3, -4, -5 and -T instead of "Statsionar-1, -2, -3, -4, -5 and -T" is used in this table for the International Registration Index (MRI) for Soviet stationary satellites.

First the distribution network was made up of a total of 20 stations located in regions of the Far East, Central Asia and the Extreme North. However, the number of stations grew rapidly with time and the "Orbita" SSS network covered newer and newer cities and regions of our country. At the present time it includes about

90 stations installed in many political-administrative centers and large cities of the Soviet Union.

Dozens of millions of people living in the extensive territory of our country now every day view the broadcasts of USSR Central Television. The distributing network of the "Orbita" stations has not lost its importance even now when the new "Moskva" distributing network of stations has begun to operate in our country in connection with the launching of stationary communications satellites of the "Gorizont" type and the "Ekran" television broadcasting system employing "Ekran" satellites has been put into service. Further development and improvement of the "Orbita" system are foreseen, along with expansion of its effective area and improvement of the quality of the operation of satellite communications receiving and transmitting equipment.

How does the "Orbita" television network operate?

Television signals are transmitted from television studios in Moscow through ground communications channels to one of the ground transmitting stations for communicating with a satellite of the "Molniya", "Raduga" or "Gorizont" type (we discussed earlier the operating and technical characteristics and structure of a station of this type). Then through the ground station's antenna they are emitted to a satellite of the "Molniya", "Raduga" or "Gorizont" type, where after reception they are relayed immediately to all receiving stations of the "Orbita" network located at the time in question in the zone of mutual radio contact from satellites and set aside for working with each specific type of satellite (fig 9).

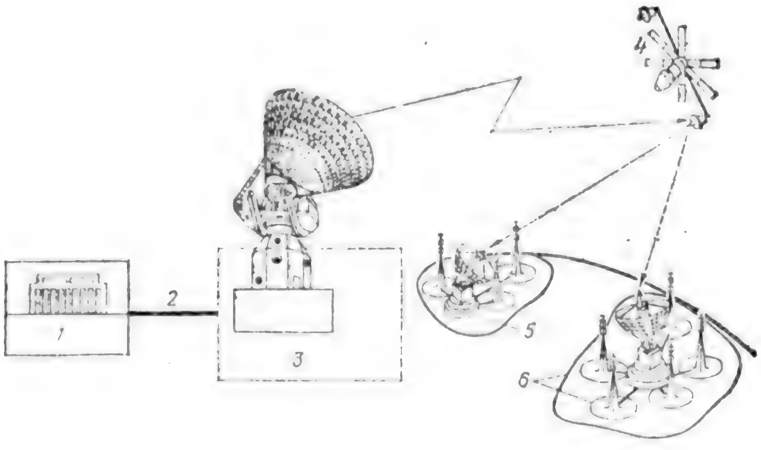

Figure 9. Diagram of Television Broadcasting by Means of "Molniya" Communications Satellite in the "Orbita" System: 1--USSR Central Television television center; 2--ground communications channel; 3--communications station of "Molniya" ground complex; 4--"Molniya" satellite; 5--receiving stations of "Orbita" network; 6--local television centers and their effective areas

Television signals received by the "Orbita" ground station from the satellite are sent to the local television center through wideband cable lines and with considerable distances through a radio relay line. Finally, the local television center by means of its transmitter and television antenna transmits and relays the television program received through the "Orbita" network to ordinary collective- or individual-use station antennas. Thus, television viewers living in the effective area of the local television center receive Central Television programs the same way as an ordinary program from their own television center.

As in the creation of other SSS ground stations, in selecting the position of stations of the "Orbita" network, in addition to the convenience of placement of a direct connecting line (cable or radio relay) to the local television center, the influence of industrial interference is also taken into account (only its most minimum value is permitted), as well as the necessity of, insofar as this is possible, avoiding the intersection of earth-satellite-earth communication directions with air routes.

Ground stations of the "Orbita" network are housed in round reinforced concrete buildings whose roof serves as a foundation for the installation of a high-efficiency parabolic antenna 12 m in diameter. The relatively small diameter of the antenna and the simplicity of its design are caused by the fairly high power of satellite transmitters and the steady orientation of satellite on-board receiving-and-transmitting antennas toward the earth. The utilization factor for the surface of the antenna of an "Orbita" station in the operating frequency band of a satellite of the "Molniya" type is about 0.7.

The successful design and high quality of manufacture of the antenna (in particular, the precision of the manufacture of the metal reflector) make it possible to use it without additional energy losses over a wide range of frequencies, including the SHF band. Experience in using "Orbita" stations has demonstrated the reliability of operation of the antenna aiming and drive systems and its certain tracking of the satellite at almost any altitude and azimuth of its position relative to the ground station.

The multiaspect development of the "Orbita" SSS has greatly expanded the capabilities of intra-Union and long-distance telephone, telegraph and phototelegraph communications, radio broadcasting, television broadcasting and the transmission of other kinds of information. The carrying capacity and branching of systems and the reliability and economic efficiency of this SSS are steadily growing. All new regions, including the most remote corners of our country, receive multiprogram television broadcasts by means of the "Orbita" system. The importance of the SSS is increasing in the control of various sectors of the national economy, in mass education systems, in systems for notifying regarding various kinds of natural phenomena and systems for rendering medical assistance.

As already mentioned, the quality of the transmission of both black-and-white and color television pictures has improved with the creation of satellites of the "Molniya-2" type operating in the SHF waveband. With the appearance of satellites of the "Molniya-3" type and the stationary "Raduga" satellite a transition was made in the Soviet Union from single-zone television broadcasting by means of the "Orbita" network to 3-zone and later to 5-zone, with respect to time zones (this will be discussed in greater detail in the following section).

"Moskva" System and Use of Soviet Satellite Communications Systems

A new television distributing network of ground stations, the "Moskva", designed for organizing a satellite communications system by means of stationary satellites of the "Gorizont" type operating in the SHF band, has been developed and put into service at the present time in the Soviet Union. "Moskva" ground stations have been set up in the European territory of the USSR, in regions of the Urals, Siberia and the Far East and in remote and nearly inaccessible regions of our country.

A special high-power "Gorizont" satellite transceiver and a narrowbeam on-board antenna which have made it possible to reduce the complexity and cost of receiving stations as compared with "Orbita" stations, are used in the "Moskva" system. "Moskva" ground stations are furnished with a parabolic antenna with a total diameter of 2.5 m, an uncooled parametric amplifier and a receiver, used for converting, demodulating and amplifying television and radio broadcasting signals. The dimensions of the equipment of "Moskva" ground stations are small and a special building is not required for it.

Signals in the 6 GHz band received by a satellite of the "Gorizont" type are converted, amplified and are transmitted in the 4 GHz band to ground stations. There they are converted to a form suitable for transmission to home receivers and are sent to the local television center, low-power repeater or to the local television distributing network. The reception and transmission of a single color television program and radio broadcast programs are thereby made possible. The signal-to-noise ratio in the picture channel is not less than 53 dB and the gain is 37.5 dB.

Satellite television broadcasting received further development in our country with the launching of stationary satellites of the "Raduga" and "Gorizont" type. Five-time-zone television broadcasting was set up via "Molniya-3", "Raduga", "Gorizont" and "Ekran" satellites in the territory of the USSR using the "Orbita", "Moskva" and "Ekran" systems. The exchange of television programs with participating countries in the international "Intersputnik" organization has also been accomplished by means of "Gorizont" satellites.

Two USSR Central Television channels are transmitted through satellites in the zone covering the European sector of the USSR located in time zones having either Moscow time or differing from it by one hour. All-Union television channel No 1 is transmitted via a "Gorizont" ("Statsionar-4") satellite to the "Moskva" station located in this zone. Moscow television channel No 4 is relayed from a ground station near Moscow through a "Raduga" ("Statsionar-3") satellite to "Orbita" stations.

Two USSR Central Television channels are transmitted via satellite to a zone having a difference of 2 and 3 h from Moscow time. All-Union television channel No 1 is relayed from a ground station near Moscow via a "Gorizont" ("Statsionar-5") satellite to the "Moskva" station network, and all-Union television channel No 2 via a "Raduga" ("Statsionar-2") satellite to the "Orbita" station network.

Two all-Union television channels are transmitted via satellite to a zone covering time zones having a difference of 4 and 5 h from Moscow time. Television reception is accomplished via a "Gorizont" ("Statsionar-5") communications satellite at an "Orbita" station and via an "Ekran" television broadcasting satellite at an "Ekran" collective-use station.

All-Union television channel No 1 is transmitted via a "Raduga" ("Statsionar-3") satellite to a zone covering the territory in which the time differs from Moscow time by 6 and 7 h.

All-Union television channel No 1 is transmitted via satellite to a zone covering the territory of the USSR in which the time differs from Moscow time by 8, 9 and 10 h. It is relayed to the "Orbita-1" station network via a "Molniya-3" satellite from a station near Moscow.

Of course, communications and television broadcasting satellites are used not only for transmitting USSR Central Television channels but also for transmitting radio broadcast programs, telephone and telegraph communications, and also for transmitting matrixes for central newspapers. For example, the "Mayak" [Beacon] radio broadcast program is transmitted via satellite to 44 "Orbita" stations and all "Ekran" professional receiving stations, from which it is relayed to home radio receivers.

Matrixes of central newspapers are transmitted from Moscow via a "Raduga" ("Statsionar-3") satellite to Khabarovsk and via a "Gorizont" ("Statsionar-5") satellite to Irkutsk and Krasnoyarsk.

It should be especially emphasized that satellites of the "Molniya" type are being used widely and successfully for purposes of transmitting information required for controlling the flight of spacecraft of the "Soyuz", "Salyut", "Venera" [Venus], "Mars", etc. type.

In the next two five-year plan periods it has been proposed to further develop satellite communications systems extensively for purposes of telephone and telegraph communications and the transmission of television and radio broadcasting programs and matrixes of central newspapers, as well as for the exchange of telecode information between the computing and data processing complexes of the YeASS being created in our country. Expansion of the distributing network of "Moskva" stations and the further improvement of all SSS's are envisioned.

"Ekran" Television Broadcasting System

The construction of ground stations of the "Orbita" type in small cities and population centers where the network of cable and radio relay communications lines is insufficiently developed nevertheless requires considerable input of equipment and capital. Special-purpose systems for television broadcasting via satellite at the present time represent an effective means capable of providing with minimum input of capital television service for peoples of countries in nearly inaccessible, remote and sparsely populated regions.

Experimental studies carried out since the beginning of the 1970's in the USSR and a number of other countries have confirmed the technical feasibility and economic efficiency of creating such systems in a relatively short time. A domestic system for direct television broadcasting using an "Ekran" satellite became the first operating system of this type in the world; beginning in 1976 USSR Central Television and radio broadcasting programs have been transmitted by means of it to nearly inaccessible and sparsely populated regions of Siberia and the Extreme North.

Unlike SSS's existing at the current time, in the system for television broadcasting via an "Ekran" satellite the reception of television programs is performed by means of inexpensive mass-produced equipment which does not require high cost for their manufacture, setup, installation and use in the ground service zone. The high-power television signal emitted from the satellite makes it possible to receive it by means of small collective antennas of a simplified type installed directly on the roofs of homes.

Only geostationary satellites are used for television broadcasting in the "Ekran" system. The use of satellites in other orbits for these purposes would require constant correction of the direction of ground antennas, would reduce the length of television broadcasts and would complicate the operation of the system to a great extent.

The accuracy of maintaining a television broadcasting satellite in stationary orbit and of orienting its on-board antennas plays a very important role in ensuring the good quality of a broadcast television picture over the entire specified service area. Errors in the orientation of on-board antennas considerably reduce the service area. For example, with an error in their orientation of 10 percent the television service zone is only about 60 percent of the maximum possible size. The accuracy of maintaining the satellite in orbit must be not worse than 0.5 to 1 degree in terms of latitude and longitude.

Modern space technology makes it possible to orient and maintain a satellite in stationary orbit with accuracy of up to 0.1 degree, making it possible to use on-board antennas with a beam width from 17 degrees (global coverage) to 2 to 4 degrees. In particular, the presence of a triaxial attitude control system in the "Ekran" satellite makes it possible to ensure the required accuracy in attitude control of the satellite in orbit.

Two "Ekran" stationary satellites are used in the television broadcasting system at "anchor station" 99 degrees east longitude ("Statsionar-T"). Their successive operation makes it possible to transmit one color television program and two radio broadcasting programs for 12 to 16 h per 24-h period.

The flight of the "Ekran" satellite is controlled by means of a ground control complex. The transmission of television and radio broadcasting programs to the "Ekran" satellite is conducted from a special ground transmitting complex at a station near Moscow. The satellite communications ground station transmitting antenna has a diameter of about 12 m with a gain of 54 dB. The maximum power in the transmitter's output is 10 kW.

The operating principle of the "Ekran" television broadcasting system reduces to the following. The television signal with the sound accompaniment arrives at the transmitting ground station from the television center through cable or radio relay lines. There the television signal is converted to a form suitable for transmission to a television broadcasting satellite, is amplified and is emitted in the direction of the satellite. The signal received by the satellite is converted with respect to frequency, is amplified, and is transmitted to all ground receiving stations located in the satellite's area.

Ground receiving stations amplify the received signal, convert it to the form necessary for reception by home television receivers and via low-power repeaters or through cable networks transmit the video signal with the sound accompaniment to television receivers. An important feature of systems for television broadcasting by means of satellites is that on the one hand a high-power signal must be emitted which is sufficient for reliable reception by very simple ground stations and on the other this signal must not create interference on the earth in the operation of ground, air and sea radio engineering facilities.

The 700 MHz and 2.5 GHz frequency bands have been assigned by international agreements for purposes of satellite television broadcasting, with the condition of the observance of norms for power density at the earth's surface, and the 11.7 to 12.5 GHz band as the most promising for direct television broadcasting satellites. Of course, the key characteristics of these systems (frequency band, radiated power, beams of on-board antennas, "anchor stations" of the satellite in stationary orbit) must be registered at ITU.

The main job of a television broadcasting satellite amounts to receiving a television signal from ground transmitting stations, converting the signal to a form convenient for transmission through space channels, and then transmitting this information to ground receiving stations located in the assigned service area of the satellite. Studies have demonstrated that for transmitting television signals through space channels it is advisable to employ frequency modulation of signals, and not amplitude modulation as used in ordinary television. In this case, although a wider frequency band is required, nevertheless the transmitter's performance can be considerably less, which is especially important for using an earth-satellite-earth link.

The "Ekran" on-board satellite repeater consists of units which receive a frequency-modulated signal from a ground transmitting station in the 6 GHz frequency band and convert this signal to the 700 MHz band, as well as equipment for transmitting the converted signal from the satellite to ground receiving stations. The output power of the on-board transmitter (with a klystron amplifier lying in outer space) is about 200 W.

The "Ekran" satellite on-board transmitting antenna, in the form of a cophased array measuring 5.7 X 2.1 m, has a 28 dB gain for the axis of the radiation pattern. A ground service area of not less than 9 million km^2 is thereby made possible. The television signal-power-to-noise ratio in the output of ground receiving stations is not less than 48 dB and the radio broadcasting signal-to-noise ratio is not less than 57 dB. The "Ekran" satellite's power supply system makes possible a power requirement of about 1.8 kW in a television and radio broadcasting session for 6 to 9 h per 24-h period.

For the purpose of receiving on the earth television and radio broadcasting programs from an "Ekran" satellite, collective-use receiving stations of two types (professional and of the set type) have been developed with simplified antennas which operate reliably under conditions of Siberia and the Extreme North. Professional-type stations, which are installed for receiving television and radio broadcasting programs primarily in cities and large population centers, make possible high quality of received programs. Stations of this type are outfitted with antennas consisting of 32 sheets of the "wave channel" type and with receiving equipment making it possible to receive, demodulate and separate picture, sound accompaniment and radio broadcasting signals.

The ratio of the power of the television signal to noise in these stations is not less than 53 dB, and of a radio broadcasting signal to noise not less than 57 dB. The television signal with the sound accompaniment separated from the received frequency-modulated signal in the 702-726 MHz band is converted into an amplitude-modulated signal, and at the frequency assigned for television transmission in the region in question is transmitted (via 100 W repeaters of the RTsTA or TRSA type) to the home television receivers the people have. Radio broadcasting programs are transmitted to local radio centers and arrive at receivers through existing networks. This receiving station of the "Ekran" system in combination with the repeater has been given the name the STV-100.

Ground stations with miniature receivers of the set type with a simplified antenna having a total of four sheets of the "wave channel" type are used for receiving television programs from an "Ekran" satellite at small, nearly inaccessible and sparsely populated centers. This set makes possible in its output a television signal-power-to-noise ratio of not less than 48 dB. After conversion of the frequency-modulated signal received from the satellite to the required form, the television signal with the sound accompaniment is transmitted via 1 and 100 W ground repeaters of the RPTN or RPTDA type or through available cable networks to home television receivers. This set in combination with the repeater has been given the name the STV-1.

The operation of the system for direct television broadcasting via an "Ekran" satellite is observed by means of a network of control stations distributed over the entire territory of the country having television service.

The series production of ground stations, antennas and repeaters is carried out by enterprises of the Ministry of the Communications Equipment Industry. Receiving stations are installed and put into service by organizations of the USSR Ministry of Communications. At the present time about 1500 "Ekran" system collective-use stations are in operation in the Soviet Union. These stations have been installed in the Kazakh SSR, the Buryat, Tuva and Yakut ASSR's, in Altayskiy, Krasnoyarskiy and Khabarovskiy krays, as well as in Amurskaya, Irkutskaya, Kemerovskaya, Magadanskaya, Novosibirskaya, Tomskaya, Tyumenskaya and Chitinskaya oblasts, including the Baykal-Amur Railroad route and other developed regions of Siberia and the Extreme North. About 22 million people live in this entire territory, and

Before the entry of the "Ekran" system into service more than 7.5 million people were not able to receive television programs.

In November 1977 the CPSU Central Committee and USSR Council of Ministers adopted the decree "Regarding Measures for Further Improvement of Cultural Services for the Rural Population." In connection with this the interested ministries and departments and individual enterprises, sovkhozes and kolkhozes can use capital arriving from various sources for the acquisition and installation in villages and settlements of collective-use ground receiving stations for receiving television and radio broadcasting programs from "Ekran" satellites.

With each year satellite communications systems will become an ever more important part of the USSR Unified Communications System.

Systems for Communicating with Moving Objects and Other Systems

It is appropriate to mention, however briefly, one more rapidly developing trend in the application of space technology--communications and radio identification equipment for ocean vessels and aircraft, as well as space search and rescue systems.

Radio navigation, radio identification based on high-precision radio measurement methods, and radio communications with aircraft and ocean vessels by means of satellites represent a separate area of the use of satellite systems for applied purposes, and generally speaking their discussion is beyond the scope of our topic. At the same time the use of radio navigation systems for communications and search needs and the use in them of many technical principles similar to those used in satellite communications systems for stationary objects to a certain extent unite these systems with satellite communications systems.

The development of satellite communications and navigation systems for ocean vessels and aircraft began in the 1960's and their improvement has taken place concomitantly with the formation of other satellite communications systems. With the growth in sea and air transport and the development of space technology, problems in the application of satellite systems for increasing shipping and air travel safety, for locating vessels and aircraft in distress for the purpose of rendering aid to them very quickly, as well as for improving the efficiency of controlling sea and air transport, have become ever more urgent.

Modern space technology has made it possible to carry out sufficiently reliably and to the required extent telephone, telegraph, television and all other forms of communication with vessels and aircraft, to make a determination of their position and to ensure efficient communication in locating and rescuing ships and their crews in distress. Satellite communications systems make it possible also to set up an efficient storm and weather warning system for the fleet, which aids in selecting safer routes, as well as the timely sheltering of craft and shortening of travelling and flying time.

Let us note here that a global international nature is characteristic of satellite navigation, radio identification, communications and search systems in aviation and sailing, perhaps more than of any other space systems. Their use is of a humane nature and is aimed in the most direct manner at protection of the environment and human life. The development of satellite communications systems based on complex stationary satellites, a drastic increase in channel capacity, multistation access, the employment of the UHF and SHF frequency bands, the rapidity of establishing communication, and automation of the control of vessels and aircraft have expanded to an ever greater extent the possibilities of using satellite communications and navigation systems for aviation and the merchant marine.

During 1971-1977 many problems were solved associated with the creation of satellite communications and radio navigation systems for ocean craft and with the development of efficient search and rescue systems. Frequency bands were established for various kinds of communication and radio identification under ordinary and emergency conditions, types of marine stations were developed and a determination was made of the principles and methods of organizing earth-ship-earth communications.

The feasibility of constructing communications and navigation systems for vessels and aircraft based on the use of both stationary and low-orbit satellites was clearly revealed, as well as the usefulness of combining in a single system all kinds of communication and location determination. The economic efficiency of satellite communications and navigation systems has increased considerably. For example, the American MARISAT navigation system now in the experimental operation stage can ensure immediate communication with 500 ocean vessels. The development of this system was completed with the placing in stationary orbit of three satellites at "anchor stations" above the Atlantic (15 degrees west longitude), Indian (73 east longitude) and Pacific (176.5 degrees east longitude) oceans.

At the present time marine navigation administrations are leasing and selling to navigation companies marine units of relatively small size requiring a fairly small amount of electric power. The ground complex of the MARISAT system includes coastal stations furnished with receiving-and-transmitting antennas 10.4 and 13 m in diameter. These stations are linked with computing and data processing complexes located at a national system control center and at a marine coordination center. These systems take care of communications with vessels and control of the fleet at sea and also make possible communication between vessels at sea and the dispatching and maintenance services of shipping lines.

In the course of the experimental operation of the MARISAT system experiments have also been conducted on the creation of a system for rendering medical aid to crews of vessels at sea by using satellites. The satellite system for medical assistance to crews of ocean vessels is based on the possibility of efficient two-way communications with any vessel at sea via satellite and of transmission to a medical center with highly skilled consulting physicians of the necessary electrocardiograms and of a television picture of the patient, of injured organs or of the operation site for the purpose of forming a diagnosis and receiving appropriate recommendations.

The use of data obtained via satellite in combination with data available at the medical center should considerably improve the quality of medical services for vessels of the merchant marine located in distant waters. In September 1976

At a session of the Intergovernmental Marine Advisory Organization an agreement was reached on the creation of the first international satellite communications and navigation system for the merchant marine, the INMARSAT. Forty countries, including the Soviet Union, agreed to participate in the creation and financing of this system. The INMARSAT system is open for participation in it by all countries expressing the desire.

Preparation of the hardware and marine equipment of the INMARSAT system is being completed at the present time. According to preliminary data, the use of improved on-line facilities for communication and determining the position of vessels will reduce the time for finding them on the voyage and will make it possible to produce a considerable savings. Work is also under way on the creation of a satellite communications and navigation system for aviation, the AEROSAT. This system will be called upon to provide reliable communications with aircraft (primarily transport) in the telephony and printing modes and the continuous determination of the position of aircraft.

Work is successfully advancing on the creation of a special satellite system for locating vessels and aircraft in distress. The Soviet Union, who is developing the KOSPAS system (for "Satellite System for Locating Vessels and Aircraft in Distress"), is participating in the implementation of this program, as well as the USA, Canada and France, who are creating the SARSAT system (for "Search and Rescue by Means of Detection with the Aid of Satellites"). Both systems are being developed so that their technical characteristics will match and they will be able to function effectively both independently, separately, and together, in coordination.

What is the principle according to which both satellite search and rescue systems will operate?

Some satellites of the system will be placed in circular circumpolar orbits at an altitude of about 1000 km. Because of this orbit these satellite with regularity due to the number of operating satellites will scan, survey and keep under constant radio control the entire surface of the globe. Ocean vessels and aircraft covered by the search and rescue services of the KOSPAS and SARSAT systems must be furnished with special emergency equipment (buoys). In cases of shipwreck or an air catastrophe conditions are created for putting these devices into operation, and every 50 s they will transmit a special distress signal.

In this signal information will be contained on the type of object in distress, its code name, the country to which it belongs, and the condition of the object. Having received this message, the "rescue" satellite will immediately transmit it to the nearest ground station for receiving distress information (PPAI). When the signal received is decoded a determination is made of the coordinates of the object in distress (at first with a precision of 2 to 4 km). The data received is quickly transmitted to the national center whose system the PPAI which received the signal is part of, and the national center transmits this data both to the country to which the vessel belongs and to all search and rescue services which can be used most quickly and effectively for rendering assistance to the craft in distress.

According to calculation data, at the initial stage of experimental operation it will take an average of no more than 2 h from the moment the distress radio buoy is switched on until its signal is received by the "rescue" satellite. Calculations have also demonstrated that the chances for saving objects in a state of distress and people having met with catastrophe increase drastically with this notification period.

Of course, if conditions permit, in addition to the satellite rescue system, in distress situations all other marine and aircraft radio equipment and other alarm and rescue systems will go into operation. However, as demonstrated by experience, when sailing in and flying over remote uninhabited regions of the Arctic, Africa, South America and the Pacific Ocean, with the loss of radio communications as the result of explosions, fire, etc., in accidents far from the routes of bustling navigation, all this information often arrives to those who would be able to render the required assistance after many hours and days, and people not infrequently perish from hunger, cold and for other reasons.

It has been proposed to locate ground stations for the reception of satellite search and rescue information in Arkhangel'sk, Vladivostok, on the coast of France, in Alaska, in Ottawa and in other places. It has been proposed to develop the launching of "rescue" satellites and experimental work involving the beginning of the experimental operation of the KOSPAS and SARSAT systems in the next five-year period.

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KATE-140 AND MKF-6M SPACE CAMERAS

Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 1, Jan 82 pp 40-41

[Article by engineer V. Kuchumov: "Space Photography"]

[Text] Space photography has at present become one of the chief methods for remote study of our planet's natural environment. From a source of data for qualitative evaluations, it has become a means for obtaining information about the quantitative characteristics of objects. This is particularly important. Today it is practically impossible to imagine the development of the major fields of earth science without space photography. Geology, hydrology, cartography, agriculture, forestry, oceanography and mineral exploration--this is far from a complete list of those sectors which employ space photographs for solving a wide circle of practical and economic problems.

Results of experiments using a modern camera system were the basis for space photography within a framework of a program to study the earth's natural resources. This program was developed by the Priroda State Center with the participation of a number of organizations from our country's various ministries and departments. Together with the solution of scientific problems, this program provides for extensive practical utilization of photographic data.

During the more than 4 years of operation of the Salyut-6 station, practically all regions of the country south of 52°N (51.6° is the station's angle of inclination) have been covered by a multitude of photographs taken in various seasons. The territories of all socialist countries participating in the Interkosmos program have been photographed.

The KATE-140 large-format topographic camera has made it possible to obtain photographs suitable for precision photographic-survey processing. It has a field of vision of 85°, which makes it possible for a single frame to contain an image of a 450x450-km segment of the earth's surface from orbital altitude. This is approximately equal to the area of the territory of Kirghizia. Precise measurement of the linear dimensions of objects and their mutual positions can be carried out on the photographs. Moreover, the camera's high resolution meets imagery-interpretation requirements. A guidance device provides for both single and strip photographs with a given interval. A punching machine is used to separate the strips.

The camera can be controlled not only with the aid of the guidance device but also from several panels located in various places in the station. The camera can also operate without the crew's participation--on radio command from earth. The times at which the camera's shutter is activated are recorded and transmitted on telemetry channels. Each of the two easily removable cassettes has a 600-frame film reserve. This makes it possible to use various types of film depending upon the missions to be carried out and the objects to be photographed.

Before being used on the Salyut-6 station, the other fixed camera, the MKF-6M, underwent thorough testing onboard the Soyuz-22 spacecraft. The multispectral MKF-6M camera is designed to obtain information about the spectral characteristics of natural objects in order to increase the reliability of their interpretation. It has six spectral channels, four of which encompass the visible spectra and two of which are in the near-infrared. Each of the six simultaneously obtained 56x81-mm spectral frames bears an image of the same section of the earth's surface, approximately 35,000 km in area. The spectral zones are selected by choosing the corresponding light filters and films based on the spectral transmission characteristics of the objects and the porthole of the spacecraft. Each of the six cassettes has a film supply of 1,200 frames. A signal is sent to the control panel at the end of the film or if the film breaks.

Precise development of calibrated shutter speeds, fixed relative-aperture values and the presence of a calibration device in the camera for the printing-in of an optical wedge provide the camera with photometric capabilities. A device to compensate for image shift and the application of specially corrected lenses and fine-grained film insure high resolving power in the photographs.

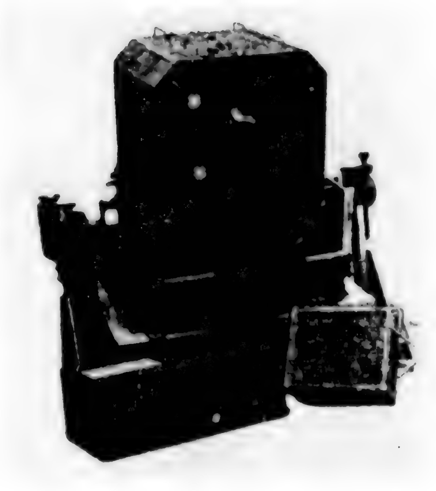
The development of materials for the MKF-6M provides for combining and comparing the images obtained in the various spectral channels. In addition to the orthoscopic qualities of the lenses (maintenance of the similarity of the object's geometric shape to its image over the entire field of view), it is necessary that the focal lengths of the lenses be equal, that there be reference crosshairs in the frame, that the optical axes of the channels be parallel and that the photographs be synchronized in order to execute these operations with a high degree of accuracy.

The crew monitors the operation of the MKF-6M by indications that arrive at the control panel. In addition, a number of parameters are relayed to earth, which makes it possible to determine not only the equipment's operational status but also to obtain data on such photographic parameters as the interval between shots and the exposure times.

The outer surface of the porthole over which the MKF-6M is mounted is protected with a cover which is opened only when photographs are being taken.

The camera's reliability, essential for flights of long duration, was increased by including a back-up electronics unit and control panel. This measure proved not to be excessive. The electronics unit malfunctioned during operations of the second major expedition. It was removed, and the reserve unit which had been delivered to the station was installed in its place. Cosmonauts V. Kovalenok and A. Ivanchenkov quickly carried out this entire operation in a coordinated fashion. The replacement of the unit had practically no effect on the planned program of photography. During the subsequent flight, the camera operated without any appreciable deviations from the norm. During the entire flight of the Salyut-6 station more than 13,000 photographic cycles were performed.

KATE-140 space camera



MKF-6M space camera

The cosmonauts took a great many photographs using hand-held cameras. They photographed atmospheric phenomena and various regions of the surface of the earth and the ocean. A number of conditions determined the feasibility of photography: first of all, the presence of fuel reserves on the station which are necessary to "construct" and maintain the required attitude; and secondly, the passage of the station's orbit over the regions which present interest. Moreover, it was necessary to consider the nature of the illumination of these regions while the photographs were being taken, the seasonal conditions of the region and the weather forecast. Photographs were usually taken when the sun was at elevations of more than 10 to 15° above the horizon and cloud cover was not more than 30 to 50 percent. Needless to say, the sun's height varied by several dozen degrees during the photographic session. These conditions determined the makeup of the camera used and the method of photography.

The initial data obtained are used to calculate the exposures, the moments at which the camera is turned on and shut off and changes in the photographic parameters. The calculated data are relayed to the station. The cosmonauts control the operation of the camera. The cosmonauts are also entrusted to make independent decisions regarding the expediency of taking photographs when the cloud cover increases along the flight route.

Before the film is returned to earth, the cosmonauts begin preparing it for chemical development. In doing so, they take into consideration the length of time the film has been in space, its initial sensitometric characteristics and data on the photographic conditions. Such preparation and the utilization of modern high-capacity equipment make it possible to develop the film and obtain materials with specified photographic parameters.

The photographic film is sent to the Priroda State Center. After processing and printing, the space data is distributed to numerous user organizations both here in our country and in socialist countries participating in the Intercosmos program.

The materials from space photography are used by many sectors of the economy to solve practical and scientific problems. In the interests of geology, for example, new information has been obtained regarding such elements of the structure of the earth's crust as fractures, ring-shaped formations and fissure zones where mineral deposits are located. Comparing data from the interpretation of space photographs with the results of land-based exploration, experts have detected structures associated with the situation of mineral deposits. They have established a number of geological mechanisms, for example, associated with the occurrence of alkaline rock which, in turn, determines the location of deposits of iron ore, rare metals, apatite and other minerals.

Space photographs were used to record numerous glacier movements and provide a quantitative analysis of them. Glaciologists relayed the information obtained to administrative and management agencies. The results of space-photograph interpretation are being extensively utilized in the composition of an atlas of the world's snow and ice reserves. The analysis of moisture reserves held in the snow and ice system and the feasibility of its economic utilization are the major applied problems for the atlas. Unique photographs of inaccessible mountain regions of the Pamir and Tyan'-Shan' have been obtained from onboard the Salyut-6 station.

In oceanographic research, space photographs make it possible to detect eddy formations (upwellings) and provide information regarding underwater contours in shoal waters and the distribution and interaction of continental currents with water from the open sea. The data obtained are used, in particular, in the interests of the fishing industry.

Space photographs have received extensive application in cartography. They are used to compare various photographic maps and plans and to update maps. Space-photograph materials have been used, for example, to create tourist and student photomaps of the region around Lake Issyk-Kul'.

Space-photograph data obtained from onboard an orbital space station and the results of the experiments performed are an important contribution to the study of our planet.

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AMERICAN PLANS FOR SPACE MILITARIZATION ATTACKED

Moscow MIROVAYA EKONOMIKA I MEZHDUNARODNYYE OTNOSHENIYA in Russian No 2, Feb 82 (signed to press 1 Jan 82) pp 15-24

[Article by S. Stashevskiy and G. Stakh: "Outer Space Must Be Peaceful"]

[Text] The rapid development of space technology has made the erection of reliable obstacles to prevent the spread of nuclear weapons to outer space, this new sphere of human exploration, one of the most urgent international objectives. Here, just as in other areas of the struggle for military detente, the Soviet Union has initiated peaceful efforts to keep all types of weapons out of space. "Let the boundless expanses of outer space," L. I. Brezhnev stressed, "be free and clear of all types of weapons. We believe in concerted efforts for the great and humane purpose of preventing the militarization of outer space."

I

Even in the very beginning of the space age, after launching the first satellite in history in 1957, the Soviet Union mapped out a specific program for the complete demilitarization of space in a memorandum of 15 March 1958 on disarmament and proposed a ban on the military use of outer space for any purpose whatsoever. Since that time the USSR has been waging a constant and tireless struggle to turn space into a zone of exclusively peaceful cooperation.

The problem of limiting the military use of space and ultimately effecting its complete demilitarization is closely related to the general problem of arms limitation and disarmament, especially in the nuclear sphere. This is due to the fact that, by virtue of the peculiarities of space technology, the powerful rocket systems which are the principal vehicle of peaceful space research are simultaneously the main vehicle for the delivery of nuclear weapons. The most destructive weapon of the present day, the strategic nuclear missile, is connected with the use of outer space because part of the trajectory of ICBM's passes through space.

As a result of the efforts of our country, supported by other peace-loving states, international treaties and agreements were drafted and concluded in the area of arms race limitation, which restricted the military use of space in some areas and prohibited the use of space for some types of military activity.

The first international agreement of this kind was the treaty banning nuclear tests in the atmosphere, outer space and under water, which was initiated by the USSR and went into effect in 1963. It was signed by more than 100 states, including three nuclear powers--the USSR, the United States and England.

The 1967 Treaty on the Principles of the Activity of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies was the next major step in the demilitarization of outer space. It records the important international legal pledge not to place in orbit around the earth any object carrying nuclear weapons or other weapons of mass destruction, install such weapons on celestial bodies or station such weapons in outer space in any other manner. The treaty prohibits the establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military maneuvers on the moon and other celestial bodies. These statements regarding the complete demilitarization of satellites and other celestial bodies were developed and made more specific in the UN-drafted agreement on the moon, which was initiated by the USSR and approved by the UN General Assembly in 1979.

Another beneficial measure to limit the military use of space was the Soviet-proposed 1977 convention prohibiting the use of means of influencing the environment for military or other hostile purposes. Its signatories pledged that they would not deliberately control natural processes to destroy, harm or injure any other states. The agreement extends to methods of influencing the atmosphere for military purposes and prohibits the use of space to change the earth's environment. Article II of this document contains the explanation that the term "means of influencing the environment" signifies any means of changing--through the deliberate control of natural process--the dynamics, composition and structure of the earth, including its biosphere, lithosphere, hydrosphere and atmosphere, or outer space.

Important provisions aimed at limiting military activity in space are recorded in the Soviet-U.S. strategic arms limitation agreements of the 1970's. The ABM treaty, the SALT I agreement and the SALT II treaty (if it had been implemented) limit the number of ICBM launchers, ballistic missiles, submarines (SLBM's) and antimissiles on both sides. This also places physical limits on the means of using space for military purposes. The agreements also record some qualitative restrictions pertaining to specific military space vehicles. In accordance with the ABM treaty, for example, the USSR and United States undertook not to develop, test or deploy space-based ABM components or systems, and the SALT II treaty envisaged a similar pledge with regard to the means of putting nuclear weapons or any other weapons of mass destruction in orbit around the earth, including semiorbital rockets.

The conclusion of these agreements brought about the complete demilitarization and neutralization of celestial bodies and limited the use of outer space for military purposes. These limitations will not be complete, however, until an effective international legal barrier is erected to impede all attempts to militarize space. The abovementioned agreements do not exclude the possibility of placing weapons which do not fall into the category of "weapons of mass destruction" in space.

With a view to this, the USSR has taken steps in other areas to further restrict the possibilities for the military use of space, thereby progressing, step by step, toward its complete demilitarization. In particular, Soviet-U.S. talks on antisatellite systems were conducted in 1978 and 1979, but they were broken off by the American side.

With the active participation of the USSR and other socialist countries, questions connected with the demilitarization of space and the prevention of an arms race in outer space were discussed at the first special session of the UN General Assembly on disarmament (1978). "To prevent an arms race in outer space," the final document of the session states, "further measures must be taken and the appropriate international negotiations must be conducted in accordance with the spirit of the treaty on the principles of the activity of states in the exploration and use of outer space, including the moon and other celestial bodies."[1]

In 1982 mankind will celebrate the 25th anniversary of the beginning of space exploration, one of the greatest achievements of science and technology. The successes of Soviet space travel are the common property of all men. The exploration of outer space has already produced great benefits in such areas as communications, the study of earth's natural resources, meteorology, navigation and many others. The abovementioned 1967 treaty on outer space recorded a broad group of principles by which states should be guided in the use of outer space for peaceful purposes. This treaty and later international agreements concluded at the initiative of the USSR and with its active participation--agreements on the rescue of astronauts, on liability for damages caused by space vehicles and on the registration of space objects in the United Nations--should establish reliable international legal order in space research and exploration.

Within the framework of the UN committee on the use of outer space for peaceful purposes, the Soviet Union is seeking a fair solution, in the interests of all states, to legal problems arising in connection with such uses of outer space as direct television broadcasting and the study of earth's natural resources from satellites and the establishment of the boundary between the atmosphere and outer space. The use of space for practical terrestrial needs was discussed at the second special UN conference on the use of outer space for peaceful purposes in Vienna in August 1982. Scientific and technical cooperation in this area is being conducted on a multilateral (through the United Nations and other international organizations) and a bilateral basis.

The socialist states are engaged in particularly close and varied cooperation in space exploration. Important research was conducted on Soviet space stations and vehicles by representatives from nine socialist countries in cooperation with Soviet cosmonauts in accordance with the Interkosmos program. Flights by Indian and French astronauts on Soviet spaceships are being planned. People of good will have fond memories of the Soviet-U.S. cooperation in peaceful space exploration, particularly the joint Soyuz-Apollo flight.

II

New possibilities for the use of outer space for constructive scientific purposes come to light each year. Today the peaceful exploration of space is one of the most important global problems whose resolution will require the concerted effort of the entire world community, truly gigantic scientific and technical resources and the intellectual potential of many peoples and states. This makes it all the more important that activity in outer space not be used for preparations for war and aggression.

However, it is precisely this path, the path of turning space into a new sphere of the arms race, that has been chosen by U.S. ruling circles. After resolving to achieve military superiority to the USSR, Washington has been paying closer attention in recent years, particularly since the beginning of the Reagan Administration, to the development and production of fundamentally new types and systems of weapons and the "exploration" of new areas of their potential use. In particular, American strategists are taking much more interest in the possibility of expanding the military use of outer space and of developing a new generation of space combat systems and deploying them in space. They hope that a "breakthrough" in the technological sphere--this time in the area of military space technology--will put the United States ahead of the Soviet Union, change the military balance in favor of the United States and guarantee it a dominant position, both in outer space and on earth. "Whoever takes the lead in space will gain overwhelming strategic superiority on earth,"[2] remarked U.S. NEWS AND WORLD REPORT, revealing the cherished hopes of the most aggressive American imperialist circles.

The influential American magazine FOREIGN POLICY has also surmised that the development of effective space-based antisatellite and antimissile systems will represent an instrument of "strategic blackmail" and a decisive means of winning a war "with one strike."[3] The head of the NASA space program division, T. Pfister, has said: "Space exploration was stimulated by the interest of the military establishment, and it has no intention of giving up the advantages it promises." The same opinion was expressed by General D. Graham, the former chief of U.S. military intelligence who was President Reagan's campaign adviser on national security matters: "Much of our military potential will eventually be located in space. The space shuttle will bring this day closer."[4]

It is no coincidence that the U.S. space program has been redesigned in the Pentagon's interest. Its expenditures on military space research far exceed the NASA budget, although it is known that many research and development projects financed by NASA are also used in military programs. According to NEWSWEEK, the Pentagon plans to spend 5.8 billion dollars on military space research just in 1982, excluding around 3 billion dollars allocated for secret military space programs. Most of these funds will be used in the development of new types of space weapons and an entire arsenal of military devices to be used for aggressive action directly in space and for the destruction of targets on the ground and in the air from space.

The Pentagon is now concentrating on perfecting the new space transport system, the space shuttle. The first launching of this kind of vehicle, the "Columbia," with two astronauts on board, took place in April, and the second was in November 1981. The shuttle program is being subordinated more and more to the interests of military agencies and is being financed by them. The original sum of 5.1 billion dollars allocated by NASA for the development of the "Columbia" was considerably supplemented by Pentagon budget funds, as a result of which the total cost of the launching program exceeded 10 billion dollars. In an attempt to convince the U.S. legislators, taxpayers and public of the need for such expenditures, Washington has spread the standard rumors about "Soviet military superiority in space."

The shuttle is to be used for the creation of orbital military stations, which will be manned by 10-14 individuals and should function permanently as space-based command points (in addition to the aircraft used for these purposes) and reconnaissance stations for the observation of objects on earth, in the air and in space.

The possibility of using the shuttle for the deployment of antiaircraft and antimissile defense systems, equipped with laser and radiation weapons, is also being considered. There have been reports, for example, of extensive and costly projects involving chemical pulse-action lasers and radiation weapons based on the use of the charged particles emitted by low-power nuclear explosions. Particularly great hopes have been placed in the laser, which would be more effective in space than on earth. Plans call for the use of space-based laser equipment not only against intercontinental ballistic missiles and satellites but also against aircraft, radar installations on earth and submarines. According to the CHICAGO TRIBUNE, the American military establishment hopes to place laser guns in space by the end of the current decade, and radiation weapons by the end of the current century. Plans have also been made for the deployment of nuclear weapons on space stations to deliver strikes against terrestrial targets.

The shuttle is to be used in the launching of relatively cheap, larger, heavier and technically perfected satellites, including attack space vehicles for diversionary actions in space. Plans also envisage space-based "space mines" (antisatellites filled with conventional explosives) and "killer satellites" for the destruction of "enemy" space objects with the aid of laser weapons or homing missiles. Some American strategists have dreamed of putting some kind of space bombers, equipped with nuclear missiles and bombs, in orbit.

According to reports in the American press, U.S. military circles are discussing the possibility of using the shuttle to conduct "inspection operations" of foreign satellites, to cause them to malfunction, to "knock" them off orbit and even to return them to earth in the shuttle's cargo bay. It is true that some foreign experts regard these plans as technically impracticable, but something else is indicative in this context: the line of reasoning of the particular U.S. circles which are obviously not averse to declaring not only immense regions on earth but also certain areas of outer space "spheres of vital American interests" and taking on the functions of a self-appointed "space policeman."

The Pentagon's plans to extend the arms race into outer space are also attested to by the establishment of a space administration as part of the U.S. military establishment.

Many foreign specialists have correctly pointed out how the world strategic situation would be destabilized by the development and deployment of effective space-based combat systems for the destruction of satellites and ballistic missiles and the disruption of antiaircraft and antimissile systems. Space-based weapon systems of this type can only be viewed as an element of "first strike" potential. The dangerous consequences of the creation of space-based ABM systems, for example, are discussed in the 1981 yearbook of the Stockholm International Peace Research Institute. The supplementation of strategic offensive weapons with this type of antimissile system, the yearbook stresses, is connected with the strategy of delivering the first nuclear strike.[5] It is no coincidence that the space-based ABM systems are to be located in such a way as to provide reliable cover for the launching facilities of the new American MX missiles. This particular function of the ABM system is mentioned, for example, in an official report which was prepared by the Los Alamos Laboratory at the Pentagon's request and contains an analysis of existing and "advanced" ABM systems.

III

Now that mankind is facing the prospect of a new and extremely dangerous round of the arms race, during which this race will spread to outer space, the USSR is proposing the only reasonable alternative--a ban on the deployment of weapons of any type in space and the preservation of space for exclusively peaceful use.

Realizing the increasing danger of the plans to militarize space and turn it into a sphere of military confrontation, the USSR set forth an important initiative in 1981: It proposed that the agenda of the 36th Session of the UN General Assembly include the question of concluding a treaty to ban the placement of weapons of all types in outer space. In a letter addressed to the UN secretary general, Soviet Foreign Minister A. A. Gromyko stressed that the Soviet Union wants space to remain free and clear of all types of weapons forever and does not want it to become a new arena of the arms race and a source of friction between states. The Soviet Union feels that an international treaty to prohibit the placement of weapons of any type in outer space would help in the attainment of these goals. At the same time, the Soviet delegation submitted a draft treaty of this type to the General Assembly for discussion. According to the draft, the signatories would pledge not to place objects carrying weapons of any type in orbit around the earth, not to establish such weapons on celestial bodies and not to deploy them in space in any other manner, including their placement on space shuttles of the existing type or any other type that might be developed by signatories in the future (Article 1). The treaty stipulates that signatories will not destroy, harm, disrupt the normal functioning or change the flight trajectory of the space objects of other signatories if these objects have been put in orbit strictly in accordance with established requirements (Article 3). According to the Soviet draft, the use of space objects by signatories would be governed by the principles of international law, including the UN Charter, in the interest of world peace and security and the development of cooperation and mutual understanding (Article 2).

The use of national technical means of control in a manner corresponding to universally accepted standards of international law is proposed as a way of ensuring the observance of treaty provisions. Each signatory should pledge not to impede the functioning of the national technical means of other signatories performing their functions according to established requirements. To promote the goals and provisions of the treaty, signatories will consult with one another when necessary and exchange information on request (Article 4). The treaty is to be in effect permanently

The implementation of the new Soviet proposal on the non-deployment of weapons in space would prevent the militarization of space and the use of space for military purposes and would simultaneously expand the dimensions of international cooperation in the use and exploration of space for peaceful, constructive purposes.

The Soviet initiative aroused great interest and won considerable support at the 36th Session of the General Assembly. Of course, the attitude toward it in the

United Nations was not, and could not have been, unanimous. The discussion of the Soviet draft led to heated debates. Delegations from the socialist and developing states and some Western countries noted the great importance of the Soviet initiative in the efforts to reduce the danger of nuclear war and curb the arms race. Only the U.S. delegation tried to oppose the inclusion of the Soviet proposal in the session agenda and prevent its discussion, obviously in the hope of influencing the position of other states which must depend on Washington to a greater degree, but it failed.

The representatives of several states expressed concern about the possible negative effects of the extension of the arms race to outer space on the cause of peace and the security of all states and stressed the need to exclude this possibility. Many speakers directed attention to the urgent need for legal standards and new agreements to prevent competition in the development and deployment of various types of weapons in space.

The Soviet proposal of a treaty banning the deployment of weapons of any type in space was supported by the socialist states at the session. "We view this as a new opportunity to prevent the outbreak of nuclear war and impede, on the basis of international law, the territorial spread of weapons," stressed GDR Foreign Minister O. Fischer. Bulgarian Minister of Foreign Affairs P. Mladenov declared that the Soviet proposal "will serve the purpose of limiting the arms race." "We, just as all peace-loving countries," said CSSR Minister of Foreign Affairs B. Chnoupek, "are exceptionally interested in ensuring that space never becomes a new arena of the arms race." According to Polish Minister of Foreign Affairs J. Czyrek, the conclusion of this kind of treaty would be "a significant restrictive measure." As Hungarian Minister of Foreign Affairs F. Puja said, his country applauds the Soviet proposals on disarmament, including the recent proposal "On the Conclusion of a Treaty To Ban the Placement of Weapons of Any Type in Outer Space," included in the session agenda. Noting the timely nature of the Soviet draft, Mongolian Minister of Foreign Affairs M. Dugersuren said that "taking action on this initiative will strengthen existing international instruments keeping space from being turned into an arena of the arms race." Lao Minister of Foreign Affairs P. Sipaseut expressed satisfaction with the new proposals submitted by the Soviet Union for UN discussion and said that they are intended to exclude the arms race from space.

There were lively responses to the Soviet initiative and approval of it from the non-aligned states. "The Soviet delegation," the representative from India said, "has correctly directed attention to the danger of an arms race in outer space." "We also support," the delegate from the PDRY said, "the proposal of an international treaty to ban the placement of weapons in outer space. We feel that this confirms the unanimous wish that outer space be free of military competition and become a sphere of peaceful activity and cooperation between states." Supporting the new Soviet initiative with regard to the demilitarization of space, Afghan Minister of Foreign Affairs S. M. Dost stressed that "this treaty will be a reliable obstacle to an arms race in outer space, which could have unforeseen consequences." The delegate from Ecuador noted that "outer space should have only peaceful dimensions" and that his side "will resolutely support any resolution aimed at avoiding the use of outer space for military purposes."

Pointing out the urgent need to take measures to prevent an arms race in space and conduct the necessary talks for this purpose, the representative from Finland said:

"We applaud the Soviet Union's recent initiative and the possibility it holds out for the further discussion of the need to secure space exclusively for peaceful purposes." According to the representative from Sweden, this country "is interested in the recent Soviet proposal of a ban on the placement of weapons of any type in outer space."

The Soviet approach to the ban on space weapons was supported by some politicians in the United States, who are disturbed by the destabilizing effect of space militarization on international relations. For example, in an article in the INTERNATIONAL HERALD TRIBUNE, former Secretary of State D. Rusk discussed the need to move ahead in the conclusion of an agreement to prevent the deployment of any type of weapon in space.

A number of statements mentioned the special role and responsibility of two "space powers"--the USSR and the United States--in the prevention of an arms race in space and appealed to them to discuss this exceptionally important problem and agree on a solution. According to the Australian representative, his country would be pleased by the conclusion of additional agreements for the use of outer space only for peaceful purposes and believes that "the most promising approach to the settlement of this vitally important problem would be the resumption of bilateral talks between the two states possessing the appropriate technology. The delegate from Ireland spoke in favor of the efforts to prevent the arms race from spreading to outer space and called upon the USSR and United States to "begin discussing the matter without delay."

With a view to the widespread support the new Soviet proposal received from the international community inside and outside the United Nations, representatives from some NATO countries also spoke in favor of measures to limit the military use of outer space. Speaking on behalf of the EEC countries, the delegate from Great Britain said: "Technical progress has expanded the possibilities of military activity by extending it to outer space. The 'Ten' attach great significance to the prevention of an arms race in space." The representative from the Netherlands remarked that the time had come long ago to seriously consider further measures to guard "outer space against an arms race.... We acknowledge that the issue of arms control in space is a complex and increasingly significant one."

At the same time, obviously in an attempt to impede the businesslike, constructive discussion of the Soviet proposals, the American representative in the First Committee, Director E. Rostow of the U.S. Arms Control and Disarmament Agency, tried to justify Washington's plans to launch a race for space weapons and to blame the Soviet Union for the lack of progress in arms control in space. Resorting to the standard propaganda ruse, he employed the intimidating threat of "Soviet attacks on the satellites of other states " Rostow tried to reduce the entire multifaceted and complex problem of keeping the arms race out of space to the partial, although important, question of land-based antisatellite systems. However, the American representative did not say a word about the fact that it was precisely the United States which had broken off the Soviet-American talks on the limitation of antisatellite systems and had never displayed any interest in resuming these talks since that time.

When the report of the UN committee on the peaceful use of outer space was discussed in the Special Political Committee, many delegations (from Austria, Indonesia, Brazil, Sweden, Ecuador, Madagascar, Nigeria, Iraq, Uruguay and Sierra Leone) not only pointed out the serious danger of the extension of the arms race to outer space but also associated the prospects for its peaceful exploration directly with the prevention of its militarization. For example, the delegate from Vietnam supported the Soviet draft treaty and stressed that if the Pentagon's plans to create space stations and vehicles armed with laser and other weapons are carried out, "the arms race in space will become a serious obstacle in the peaceful relations between states and a serious threat to peace and security."

The representative from Austria stressed that "the peaceful use of space can only be productive if this sphere of human activity is used exclusively for peaceful purposes." The delegates from Sweden and Brazil called for concrete steps to keep space from turning into a new region of hostilities.

After all of the debates, the UN General Assembly approved, by an overwhelming majority, a resolution supporting the Soviet proposal on the conclusion of a treaty to ban the placement of weapons of any type in outer space. The resolution was supported by 123 states (socialist, non-aligned and some Western states). No one voted against it, but 21 delegations abstained (including the United States, other NATO countries, Australia, Japan and Israel). The resolution says that the General Assembly, hoping to prevent outer space from becoming an arena of the arms race and a source of friction between states, "feels that the appropriate international treaty should be concluded so that effective measures can be taken to keep the arms race from spreading to outer space" and "asks the Disarmament Committee to organize talks on the text of this treaty."[6]

It is one of the international community's most important duties to exclude the possibility that space will become a source of military danger to states, which will be the unavoidable result of the saturation of outer space with various weapons. It was precisely this noble goal that the Soviet Union was pursuing when it submitted its proposal on the prohibition of weapons in outer space to the United Nations.

The broad support the Soviet proposal gained at the 36th Session of the General Assembly and the adoption of the resolution calling for the drafting of this kind of treaty in the Committee on Disarmament represent a tremendous and positive UN contribution to the resolution of a problem of truly permanent global significance. Delegates from all states represented in the committee now have a clear and concise document expressing the intention to take a serious and businesslike approach to the prevention of an arms race in space and the conclusion of the appropriate international agreement.

The discussion of the Soviet proposal in the United Nations and the decision adopted in this connection have once again provided clear evidence of the USSR's role as the vanguard in the struggle for arms limitation and disarmament. The discussion at the 36th Session of the General Assembly once again demonstrated the Soviet Union's constant willingness to conduct talks--businesslike, honest talks on an equal basis--on any way of curbing the arms race, and our country's determination to attain constructive agreements on the demilitarization of space for the purpose of eliminating the threat of war and consolidating peace on the planet.

FOOTNOTES

1. Doc UN A/Res/S-10/2, p 11.
2. U.S. NEWS AND WORLD REPORT, 27 July 1981, p 46.
3. FOREIGN POLICY, Fall 1981, p 99.
4. NEWSWEEK, 27 April 1981, p 19.
5. "World Armaments and Disarmament. SIPRI Yearbook 1981," London, 1981, p XXIV.
6. Doc UN A/Res 36/99.

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LAUNCH TABLE

LIST OF RECENT SOVIET SPACE LAUNCHES

Moscow TASS in English or Russian various dates

[Summary]

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
15 Mar 82	Gorizont	36,220 km	--	24 hrs 23 min	0.7
		(Communications satellite carrying multichannel relay equipment for telephone, telegraph and TV transmission; near-stationary circular orbit)			
17 Mar 82	Cosmos-1343	314 km	208 km	89.4 min	72.9
24 Mar 82	Molniya-3	40,615 km	656 km	12 hrs 16 min	62.9
		(Communications satellite for long-range telephone, telegraph and TV broadcasts in "Orbita" network)			
24 Mar 82	Cosmos-1344	1,023 km	987 km	105 min	82.9
25 Mar 82	Meteor-2	976 km	954 km	104.2 min	82.5
		(Meteorological satellite to obtain global pictures of cloud cover and earth's surface in visible and IR range both in memory and direct transmission modes; data received by State Research Center for Study of Natural Resources and USSR Hydromet Center)			
31 Mar 82	Cosmos-1345	550 km	507 km	95.2 min	74
31 Mar 82	Cosmos-1346	675 km	623 km	97.6 min	81
2 Apr 82	Cosmos-1347	364 km	181 km	89.7 min	70.4
7 Apr 82	Cosmos-1348	39,342 km	613 km	11 hrs 49 min	62.8
8 Apr 82	Cosmos-1349	1,025 km	984 km	105 min	83

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
15 Apr 82	Cosmos-1350	380 km	181 km	89.8 min	67.2
21 Apr 82	Cosmos-1351	555 km	349 km	93.5 min	50.7
21 Apr 82	Cosmos-1352	383 km	216 km	90.2 min	70.4
23 Apr 82	Cosmos-1353	269 km	218 km	89.1 min	82.3
		(Information received will be processed at the "Priroda" research and production center)			
28 Apr 82	Cosmos-1354	829 km	795 km	101 min	74
29 Apr 82	Cosmos-1355	459 km	438 km	93.3 min	65.1
5 May 82	Cosmos-1356	684 km	632 km	97.6 min	81.2
6 May 82	Cosmos-1357-- Cosmos-1364	1,520 km	1,449 km	115.4 min	74
		(Eight satellites launched by single booster)			
15 May 82	Cosmos-1365	276 km	259 km	89.6 min	65
18 May 82	Cosmos-1366	35,820 km	--	23 hrs 57 min	1.5
		(Carries experimental equipment operating in SHF band for transmission of telephone and telegraph information; circular orbit)			
20 May 82	Cosmos-1367	39,530 km	612 km	11 hrs 49 min	62.8
21 May 82	Cosmos-1368	365 km	218 km	90 min	70.4
25 May 82	Cosmos-1369	296 km	229 km	89.4 min	82.3
		(Carries equipment for study of natural resources of the earth)			
28 May 82	Cosmos-1370	290 km	203 km	89.2 min	64.9
29 May 82	Molniya-1	40,633 km	653 km	12 hrs 16 min	62.8
		(Communications satellite for telephone and telegraph communication and transmission of USSR Central Television programs to stations in the "Orbita" network)			
1 Jun 82	Cosmos-1371	833 km	793 km	101 min	74.1
1 Jun 82	Cosmos-1372	277 km	258 km	89.6 min	65
2 Jun 82	Cosmos-1373	368 km	217 km	90.1 min	70.4

Date	Designation	Orbital Parameters			
		Apogee	Perigee	Period	Inclination
4 Jun 82	Cosmos-1374	225 km	--	--	50.7
		(Circular orbit; no period of revolution reported; launch announcement includes statement: "scientific research envisaged by the program has been carried out.")			
6 Jun 82	Cosmos-1375	1,021 km	990 km	105 min	65.9
8 Jun 82	Cosmos-1376	274 km	227 km	89.2 min	82.3
		(Carries equipment for earth resources study; data will be processed at the "Priroda" State Research and Production Center)			
8 Jun 82	Cosmos-1377	362 km	179 km	89.7 min	64.9

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